Metal Additive Manufacturing and Firearms—An Intersecting Opportunity

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Metal Additive Manufacturing and Firearms—An Intersecting Opportunity

In a continued mission to move metal additive manufacturing technologies further into the global manufacturing community, the concurrent efforts to develop new applications while refining processes have brought metal AM into exciting new possibilities beyond the early adopter markets of aerospace and orthopedics. A myriad of economic, political, and technical factors may be forming to create a new significant market for several metal AM technologies in a global industry worth an estimated $11B in the U.S. alone—firearms.

Small Arms Silencers—an Application Ripe for Innovation by AM

Globally, the use of silencers for small arms, including rifles and pistols, is common. Such devices are utilized increasingly in military operations for strategic reasons, but have a long history as a shooting accessory in civilian firearms use worldwide as a matter of public health to reduce noise pollution associated with hunting and recreational shooting. In a number of countries throughout Europe, use of firearm silencers is relatively widespread as a safety device to reduce hearing loss associated with firearm use in civilian applications. Despite their currently heavily regulated nature in the United States—the world's largest civilian firearms market—there are still an estimated 1.3 million silencers registered and in use among recreational and professional shooters.

For additive manufacturing, the powder bed fusion process is already well positioned to advance the technical performance and quality of firearm silencers, and a number of commercial production applications have now begun in this area.

Powder bed fusion technology is a strong fit for silencer production in two key ways.

First, many of the materials that have already been qualified for use in the process are also industry standard materials in subtractive or traditional silencer production. Second, and more importantly, the alleviation of design constraints associated with subtractive machining technologies can improve silencer value in vital areas including overall weight and back-pressure performance, translating into more effective sound reduction, durability, and shooting performance. Firearm silencers work because they allow for a controlled expansion chamber for gases exiting the barrel of a firearm which is a primary cause of explosive noise. By allowing for the manufacture of very complex geometries, a superior control of gaseous expansion can be achieved, while also optimizing weight without added machining time.

Since 2015, several silencer manufacturers have embraced additive manufacturing for the benefits described above and more. Initial adoption was with specialty and smaller engineering firms both inside and outside of the firearms industry, such as

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Tonrud Engineering, which has been producing a titanium rifle silencer since 2015. Other global producers such as Oceana Defense in New Zealand have also been among the earliest adopters of various powder bed fusion technologies for silencer production.

Stateside, firms such as Delta P Design, which have also been experimenting with laser powder bed fusion as a manufacturing process for various silencer designs since perhaps even before 2015, now have several models currently in early production. The Brevis II is one particular example from Delta P which features a very short and lightweight design that relies on the manufacturing freedom of AM to create a much larger gas expansion chamber than would be possible in such a small silencer made by traditional means.

But the real trend appears to be just beginning for silencer manufacturing using AM. Perhaps the most influential stamp of approval for additive production of firearm silencers came recently in 2017 when Department of Defense supplier and renowned creator of semiautomatic AR-15 rifles, Daniel Defense announced it would release the Wave "3D printed suppressor" this year. Not only does Daniel Defense represent the most influential industry name to adopt additive manufacturing in such a public way, it also is significant as the Wave will be Daniel Defense's first product in the silencer market. Sig Sauer, which has greatly expanded its business into firearms accessories to include silencers within the last two years, has also tested additively manufactured silencers designed for use with fully automatic firearms for military applications (but has not thus far produced any in an end-use application with AM).

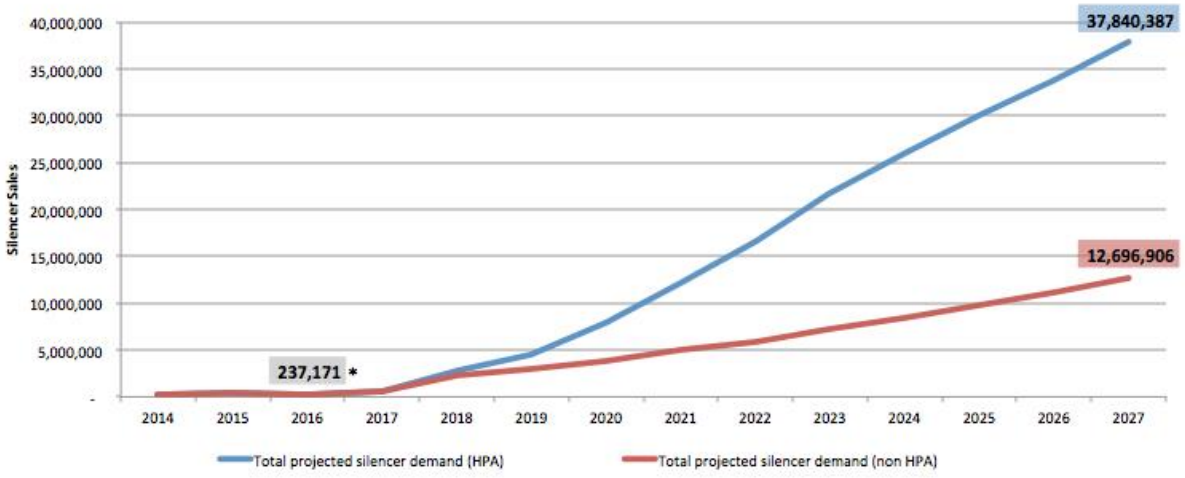
Clearly, the largest names in firearms for both military and civilian markets are beginning to take a larger interest in additive manufacturing, but also silencer markets overall. Why?

Massive Worldwide Growth in Demand for Firearm Silencers on the Horizon

Use of silencers in military applications varies significantly, though widespread use has historically not been common, relegated mostly to specialty units and operations as a means to eliminate the report of firing a weapon from a concealed position. Widespread issuing of silencers within general infantry units has historically been limited due to increased maintenance requirements, costs, and a lack of research and data on the service life and effectiveness of silencers in infantry applications.

However, a number of factors today are rapidly changing the demand dynamics for small arm silencers (especially in the U.S.), with additive manufacturing technologies already positioned to play a role in the future of this potentially rapidly expanding application.

Total Projected Worldwide Firearm Silencer Demand, Civilian + Non Civilian, 2014-2027(e), by Scenario



**2016 data is heavily influenced by reported data from the ATF for silencer ownership applications. Due to implementation of ATF 41P/41F numbers for the 2015-2017 period may be skewed due to significant backlogs created in approval of silencer ownership applications.*

Shown above, SmarTech estimates the annual worldwide demand for firearm silencers, in aggregate of both military and civilian markets, for two adoption scenarios. In red, potential demand is modeled based on the current market situation in the U.S. where firearms silencers remain a Class III NFA item with extensive regulatory requirements for civilian ownership. In blue, a second scenario is modeled that assumes a deregulation scenario for civilian ownership of silencers in the U.S., such as the passing of the Hearing Protection Act or similar legislation in late 2017 to mid-2018.

Worldwide demand for firearms silencers across military and civilian applications is difficult to estimate given the secrecy around military purchasing and infantry strategy evolution, but SmarTech Publishing estimates the global annual demand—which has grown significantly over the last five years thanks to civilian market demand—is around 1.1 million per year. This creates a market opportunity of between $1 billion and $1.5 billion per year today. Significant growth in demand for small arm silencers, particularly for centerfire rifles, has already been noted in the U.S. over the past two years. SilencerCo, a leading manufacturer of silencers located in the U.S., noted last year that its production of traditionally manufactured silencers has grown to 18,000 silencers per month. SilencerCo believes that its monthly production volume today is roughly equivalent to the entirety of the annual U.S. silencer production volume from a decade prior in 2006.

Much of this increase, which is reflected across the entire U.S. silencer industry, has been attributed to growing demand from the civilian market desiring the hearing safety benefits for silencers in shooting sports. For the civilian market, however, the growth in demand has likely only just begun.

The silencer industry is currently struggling with the effects of politically-driven industry bottlenecks that have greatly affected the massive demand growth pattern observed from the past several years. This has led to political activism to reduce government obstruction to silencer ownership in the form of legislation such as the Hearing Protection Act (HPA), which was introduced in 2015, but has recently gained significantly improved awareness and legislative traction in the U.S. The bill seeks to remove firearm silencers from the National Firearms Act (NFA) which currently requires a more extensive approval process from the ATF, and allow their sale through a more streamlined process similar to firearms in the U.S., following the same instant criminal background check rather than the submission of multiple forms and tax-stamp applications to the ATF. That process has created huge approvals bottleneck—current wait times for silencer ownership approvals have exceeded one year in recent months.

With the potential of a greatly increased access to silencers for the civilian market in the largest civilian firearms market in the world, the broader firearms industry is positioning itself for massive increases in demand that could come almost overnight should legislation be approved. The risks of such strategic investments in silencer production and design by firms in the firearms industry are likely being assuaged by the historical growth in demand even under the current burdens of the NFA.

Potential silencer demand increases are also seemingly imminent from the military market as well, further catalyzing the industry to prepare for a future where silencers are among the most widely produced small arms accessories. In 2016, the 2nd Marine Division of the U.S. Marine Corps announced a series of proof-of-concept tests for the use of silencers on every element of an infantry battalion in real-world theater of war. Leaders close to the project site an increase in the effectiveness of communication ability with the reduction in noise during engagements. This allows for better control and execution, but also noted improvements in actual combat performance metrics such as accuracy, because infantrymen are able to better focus on their actual shooting effects on targets.

In 2017, both the Army and Marine Corps announced further interest in procuring silencers for expanded infantry use. Though sources report the Marine Corps is more enthusiastic, the Army has notably included in its recent bid for a new interim combat service rifle to replace the M16/M4 platform the requirement for any considered new platform to accept silencers. The same was true in the recent Army 'Modular Handgun System' contract awarded to Sig Sauer.

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More Silencers, Made Better Through Additive Manufacturing

To be sure, additive manufacturing will not become the sole manufacturing process for firearm silencers. Traditional silencer design and manufacturing will remain common, especially in a market scenario where silencer demand grows exponentially through easier access to civilians in the U.S. Subtractive milling from 17-4 stainless steel, Inconel alloys such as 718, titanium, and even aluminum will likely remain a majority share of manufacturing. Should silencers become significantly more ubiquitous in the next five to ten years thanks to the Hearing Protection Act or similar legislative efforts, comparatively lower value products (even "disposable" silencers) will no doubt keep milling technology relevant for decades to come.

However, AM is clearly positioned in an increasingly familiar high value silencer application, where the cutting edge of silencer performance can clearly be improved thanks to additive manufacturing. This will no doubt appeal to military applications in which service life for silencers for widespread infantry use can be increased through use of one-piece designs. Meanwhile, AM appears well poised to take over specialty silencer applications seen today by allowing for lighter and shorter designs that appeal to both enthusiasts and special operations units.

The phenomenon of back-pressure in silencers can also be addressed through the design freedom afforded by additive manufacturing. Back pressure refers to gases escaping rearward toward the user of a firearm as the result of using a silencer to control and slow the expansion of gas out of the barrel. Back pressure can increase wear on a firearm, and on common rifle platforms such as the AR-15 or M4 can also disrupt the shooter by escaping the rifle near the shooter's face.

Additive manufacturing allows for more complex internal geometries in the silencer baffles, which are designed to slow and control gases escaping the barrel. This design freedom can be applied to reduce rearward escape of gas, while also potentially allowing for improved sound attenuation.

For now, such applications to improve silencer performance definitely come at a cost—the few commercially available additively manufactured silencers are among the most expensive on the market today. The average cost of production silencers on the civilian market (which do not differ significantly from those utilized by the military) is between $600 to $900, while additively manufactured silencers such as the DD Wave and Delta P Design Brevis start around $1,200 and increase up to $2,000 in some cases.

However, the silencer industry isn't the only one that is facing enormous change. Metal AM technologies are also expanding into new areas, with new processes seeking to bring down costs while expanding the available material sets and applications to possibly move adoption of AM for firearm applications beyond just silencers.

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Moving Metal AM Into Less Extreme Applications

For the past five years, the theme of metal additive manufacturing (and 3D printing as a whole), has been about the transition to manufacturing of production components and the disruption this may have on not only supply chains, but on how commercial products and industrial tools using metal subcomponents are designed.

Today, the conversation is beginning to shift towards an expansion of that vision. With bona fide production now underway for a variety of aerospace engine components (with many more aircraft applications on the horizon), and the orthopedic industry rapidly adopting AM as both a design principle and production method, market leaders are beginning to address how to grow the impact even further in a shorter period of time.

This is a complex challenge, but in general, the adoption of metal AM as a production process is ideal only in a set of manufacturing circumstances which don't widely exist throughout the world today. Over time, there can be no doubt that the industry will grow through an eventual build up in expertise related to design for additive manufacturing. However, given the cost structure of current technologies, most feasible applications are for very high value or critical components. In addition, with popular powder bed technologies that have the greatest ability to produce highly complex parts with very small minimum feature size, larger parts remain economically challenging.

In short, until the world's manufacturing communities are able to better grasp both the principles of design for additive manufacturing while also gaining the necessary process expertise to maintain a tighter control of the economics and outcomes, AM will remain a production process for parts of very high value, in lower relative volumes.

For the firearms industry, even in this scenario, there is already a home-run application in firearm silencers. For prototyping of less high-performance parts, metal AM is still likely to grow significantly among firearms manufacturers through the release of much lower cost powder bed fusion systems such as the ORLAS Creator from German OR Laser.

However, a new set of processes based around metal binder jetting and bound metal powder processing using a two-stage process may leapfrog their way into significance for firearms applications. Desktop Metal and Markforged are two providers that have recently launched new metal AM technologies which significantly reduce hardware costs, while also expanding the range of available materials significantly by utilizing two-stage processing with post-printed sintering and metallurgical properties based around metal injection molding (MIM).

Though it's no secret that MIM does not have an outstanding reputation among firearms engineers, its use continues to spread in global firearm design due to cost advantages. For additive manufacturing, the introduction of such processes, which are targeting less complex, lower-value parts brings a new element to the adoption of AM for firearms components and accessory manufacturing. Should processes from Desktop Metal, Markforged, or any other comparatively low-cost metal AM process enable printing in aircraft grade aluminum alloys which are the most commonly used alloy in many firearm accessory and receiver components, adoption of AM by specialty and large firearms components manufacturers could skyrocket. In the U.S., there are dozens of firearms component and accessory manufacturers for aftermarket accessories serving the 300 million-plus guns privately owned in America.

For now, metal AM technologies such as powder bed fusion will see continued growth in silencers—with potential for major growth pending legislative efforts in the Hearing Protection Act, SHUSH Act, and increased military adoption. In the future, the groundswell of new AM processes would do well to target firearms-related applications with cost-effective production of parts in 7075 and 6061 aluminum yielding metallurgical quality at least as good—if not exceeding—metal injection molding processes. With these two growth factors in play, **SmarTech Publishing** anticipates that adoption of AM by the broader firearms industry could generate up to $1B in opportunities over the next decade.

About SmarTech

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