

# HOW TO POSITION YOUR COMPANY IN THE 3D-PRINTING VALUE CHAIN

By Mel Wolfgang, Claudio Knizek, Daniel Küpper, Amit Ganeriwalla, Janice Lee, and William Herbert

**A**FTER 25 YEARS OF much-hyped development, additive manufacturing (AM)—the industrial version of 3D printing—is finally in the next phase of maturity and moving into production. Suddenly, a process that once seemed far in the future is fast becoming a reality, and it is poised for rapid growth. In 2015, the entire 3D-printing market—which includes products made from plastics, ceramics, and metals—totaled \$5 billion. BCG expects this market to triple by 2020. Forward-looking companies along the value chain in a variety of manufacturing industries are now trying to determine whether, and how, to capitalize on this quickly developing market.

The AM market is expected to reach \$350 billion by 2035. The metal segment of that market is especially promising and will likely account for one-third of it by the same year. Metals such as titanium, steel, nickel, aluminum, and cobalt alloys are used to make high-performance parts, especially in the aerospace and medical industries. AM builds 3D objects by using dig-

ital designs and specialized equipment to create multiple, ultrathin layers of material with minimal waste. This additive approach is the opposite of the traditional, or subtractive, manufacturing process, in which shapes are cut out of a piece of bulk metal and products are created using labor-intensive tasks such as machining, welding, or casting.

Because it has fewer manufacturing restrictions, AM gives engineers greater design freedom. Other benefits include less waste, greater production flexibility for just-in-time parts, lower material and labor costs, and accelerated speed to market for new designs. For example, a 20-part aerospace subassembly welded into final form can have a lead time of up to 14 months. An AM replacement, however, can be made in less than 1 month—with 90% less scrap. Parts can be optimized for strength, durability, heat resistance, and weight, depending on the materials used. For these reasons, AM lends itself to complex or highly customized products and small batch production.

## How Industry Players Are Responding

Although technical and economic challenges still must be overcome, the media is positioning AM as the next industrial revolution. (See “Biomedical 3-D Printing: A Niche Technology or the Next Big Thing?” BCG article, September 2015.) According to Jeff Immelt, the chairman and CEO of GE, “Additive manufacturing is a key part of GE’s evolution into a digital company.” In July 2016, the company introduced its first AM component: fuel nozzles for the LEAP jet engine. The company expects to be making 40,000 units per year by 2020, a tantalizing glimpse into the possibility of AM mass production. In the fall of 2016, GE acquired two suppliers of AM equipment, Concept Laser and Arcam, further signaling its commitment to AM.

Other players in the aerospace, medical, industrial tooling, energy, and automotive sectors are also pushing to integrate metal AM technology into their supply chains. Since 2012, companies in the private sector have invested more than \$1 billion in R&D facilities, AM centers of excellence, and pi-

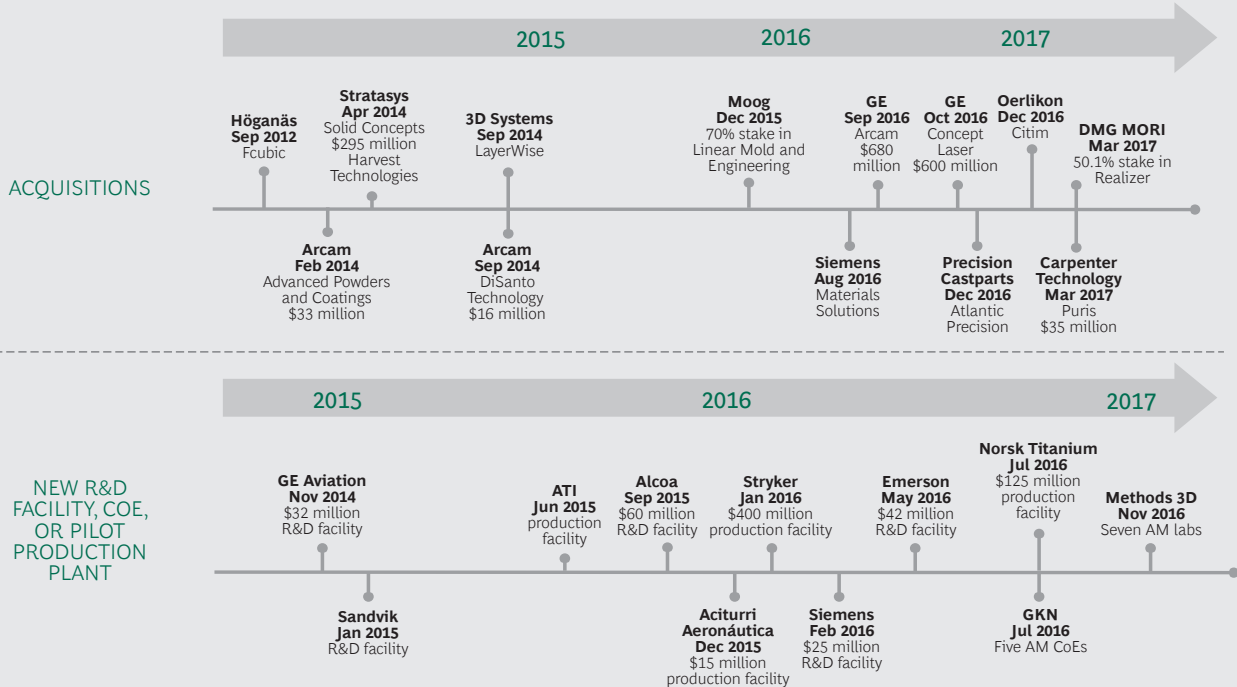
lot production plants. Dealmaking activity has increased in recent years, with large industrial conglomerates seeking to acquire AM systems specialists or contract manufacturers. (See Exhibit 1.)

Growing activity suggests that there may be many ways to capitalize on this market and that value chain players should be seriously thinking about their AM roles and strategies.

## Priorities for Value Chain Players

As metal AM moves from niche design tool to widespread industrial use, companies must consider their future positioning and strategic options—both defensive and offensive. Some manufacturers may believe that parts of their traditional businesses could one day be threatened by metal AM and seek ways to protect their interests. Others will want to act aggressively to gain a first-mover advantage. In either case, efforts may include investing in R&D, building internal capabilities, forming strategic partnerships, acquiring AM companies, or

**EXHIBIT 1 | AM Dealmaking Activity Has Grown in Recent Years**



Sources: Metal AM magazine; Wohlers Associates; BCG research.

Note: CoE = center of excellence. All dates indicated are for initial announcement, not actual transaction or establishment date. Information about the value of a transaction or a new facility was included only if publicly disclosed.

vertically integrating. Some players may decide to make AM components in-house, while others will outsource production to a knowledgeable partner. Given a steep learning curve and a scarcity of experienced engineers and technicians, industry players may have to consider acquisitions to enter the metal AM space.

To get started, companies along the value chain must identify their key sources of differentiation, assess their strengths relative to other players, and determine the best strategic moves. (See Exhibit 2.) Depending on their position, these companies will have different priorities.

**Alloy Manufacturers and Suppliers.**

Companies in this category are experiencing growing demand for the high-quality metal powders and wire feedstock used in AM. The priority for materials suppliers should be to stay close to equipment makers and other end users as they develop and certify new components. Once parts makers become used to a particular feedstock and have obtained regulatory approval for its use, switching providers becomes costly.

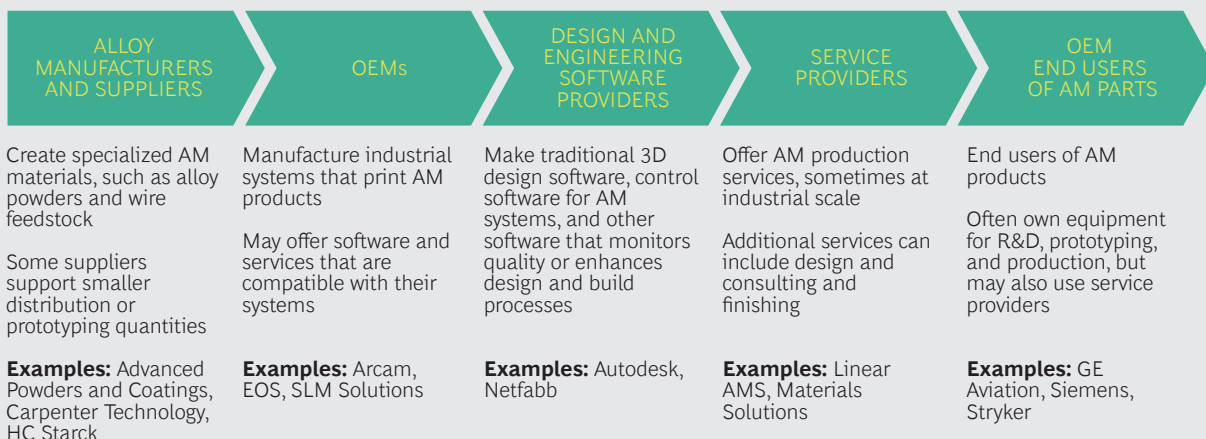
However, existing materials are not optimized for state-of-the-art AM processes, and some of the more basic alloy grades in use today may become commoditized over the medium term. To retain competitive advantage, materials suppliers should in-

vest in R&D for novel or lower-cost materials designed specifically for AM. Finally, both materials and equipment suppliers must continue to focus on improving output consistency and reliability among AM processes. To accelerate the broad adoption of AM and their products, companies could participate in collaborative data capture projects, such as the NIST Additive Manufacturing Materials Database.

**OEMs.** These manufacturers already hold much of the core intellectual property in the field, and the share prices of established players reflect high growth expectations. But they face threats arising from further industry consolidation (following the recent GE acquisitions) and from new entrants. Today, more than 40 equipment makers cover the main AM modalities—including powder, direct metal deposition, and binder jetting—and new companies enter the market every year.

Given the highly fragmented market and the looming threat of consolidation, machine manufacturers must differentiate themselves in one or more key areas, such as greater reliability, faster speeds, better quality, expertise in a wider range of materials, a simpler user interface, or easier setup and handling. Manufacturers also must gain traction by working closely with key service providers and end users, continuing to invest in R&D, and building up a workforce with AM expertise.

**EXHIBIT 2 | Players in the AM Value Chain Must Assess Their Roles and Strategies**



Source: BCG analysis.

**Design and Engineering Software Providers.** Companies in this category include those that make traditional computer-aided-design software, control software for AM systems, topology-optimizing algorithms, and other software that monitors quality or enhances design-and-build processes. Their role is to improve program usability in order to enable rapid prototyping and to ensure that their software will work with a variety of AM machines and systems.

To this end, a key strategic priority is to stay close to AM equipment makers. Also important is getting user feedback and staying on the leading edge of innovation. Protecting intellectual property will be a critical concern as well, since designs are sent digitally to manufacturing sites around the globe. In traditional manufacturing, process complexity acts as a barrier to entry to would-be copycats, but AM software stored in digital format can be replicated by just pressing a button.

**Service Providers.** These job shops offer AM production services, sometimes at industrial scale. They also partner with OEMs and other end users that lack the expertise needed to ramp up AM production technology. Because this technology is still in its early stages, the services most likely to be highly valued by customers are application design and consulting. But customers may also look for full-contract manufacturing, in which AM is combined with conventional machining and finishing to provide off-the-shelf, finished parts.

To keep the outsourcing model attractive, these players must stay ahead of the curve as knowledge centers and leaders in cost-efficiency. They should also work closely with a single large customer, such as an OEM, to essentially become an affiliated AM division—with the potential of a future merger and relatively seamless integration. Materials Solutions and Siemens formed this type of partnership in 2016. But because most service providers are small, and the space is fragmented, the need to make an inorganic move is only moderate.

**OEM End Users of AM Parts.** These players could reap the greatest potential benefits from new-product development in AM and lower manufacturing costs, so their role is to stay on the leading edge of the technology and push the boundaries of design in their products. Because AM may be a game-changer, OEMs must act now or risk rendering their products, or even whole business segments, obsolete in the future.

Where possible, these companies should quantify the value that AM could deliver in speeding up new-product development, cutting manufacturing costs, providing value-added services such as customization, and freeing up working capital across the supply chain. And because of the rapid pace of innovation in the metal AM sector, companies will need to weigh the tradeoffs between building internal capabilities and acquiring companies that already have AM expertise. They will also need to ensure that their AM parts are qualified for service by collaborating with standardization committees—a process that can take many years in safety-critical sectors, such as aerospace and health care.

## Taking Action

Although most observers believe that the AM industry will continue to grow rapidly, the full potential of AM technology is unknown. No clear winning business model or dominant technology has yet emerged. Raw materials, AM equipment, and contract manufacturing may become commoditized over time. Without a crystal ball, it's difficult to predict which actions will create the most value for supply chain players over the medium to long term, so timing is critical. Companies that want to capitalize on the promise of AM must balance the risks and the opportunities when entering the market. Best-practice companies in the field have taken three approaches:

- **Monitoring and Preparing.** At the very least, companies should stay plugged into new industry developments. We recommend setting up a cross-functional AM focus team to gather information on new developments, attend relevant

conferences, develop a high-level strategy roadmap, and keep management informed of AM developments. Consider keeping a list of potential partners or acquisition targets so you can move quickly as the landscape evolves, and be prepared when potential partners or collaborators approach you. To remain engaged on the R&D side, focus on innovative product design and outsource as needed for prototyping and pilot scale-ups. Taking this position has two primary risks: first, you may be giving too much market power to competitors that are vertically integrating or taking other, more aggressive action; and second, the opportunity cost of not investing more in a growing market may be high. But if your company passively reacts to market developments rather than actively shaping them, you may be left with the scraps.

- **Developing Proprietary Technology and Products.** Companies that both see significant potential in AM (such as manufacturers or buyers of complex, precision, or customized parts) and have resources available may want to invest in their own internal capabilities. Consider building an R&D center of excellence to stimulate engineering efforts, forming partnerships with adjacent players in the value chain, or making strategic investments in up-and-coming AM businesses. OEMs such as Siemens, Emerson, GKN Aerospace, and Stryker are taking this route, and materials companies such as Arconic, Oerlikon, and Sandvik have also opened or announced multimillion-dollar AM facilities.

- **Acquiring or vertically integrating.** This option may make sense for companies with immediate production needs that justify a large investment or for those that want to make an early move to corner what they think may be a valuable portion of the AM value chain. The market is already showing evidence of consolidation and vertical integration: GE has made multiple acquisitions, Siemens took a stake in service bureau Materials Solutions, Oerlikon acquired service bureau Citim, machine manufacturer Arcam bought powder producer Advanced Powders and Coatings, and specialty alloy maker Carpenter Technology acquired Puris, a producer of titanium powder. (Author William Herbert is the director of corporate development at Carpenter.) This activity could spur other industrial competitors to get involved for fear of losing out. But given the hype premium that many acquirers are paying, buying your way into the AM market is viable only if your company has a clear vision of how to generate value from AM—and the skills to execute.

The choice of approach and timing will vary for each player along the AM value chain. Although the technology's promise may take many years to fully materialize, the potential for growth—and for industry disruption—is far too great for your company not to consider its strategic options.

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