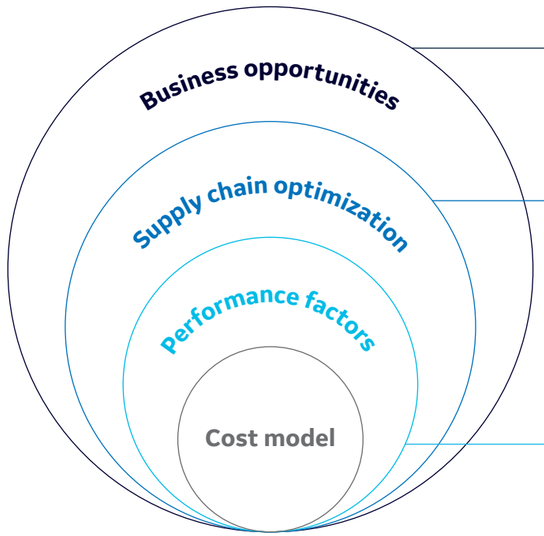
Industrial Solutions from GE Additive

Realize ROI
with metal additive.

Mold making. Die casting. Tool making. Now, the ready are evaluating how additive can drive greater returns on investment. Discover your additive advantage, from new business opportunities with tool steel and pure copper to reducing warpage on molded parts with conformal cooling.

Thinking through the bigger business case



- New customers and markets
- Clear competitive advantage due to product differentiation
- Accelerate time to market

- Part consolidation
- Inventory reduction
- Purchase order reduction
- In-housing of tooling operations and production
- Reduced workflow
- Lead-time reduction

- Weight reduction
- Greater efficiencies
- Enhanced reliability
- Improved part performance
- Reduced distortion of the final product
- Additional functionality

How much further can additive take you?

Consolidate parts
Anesthesia Serenity Vaporizer Manifold

From: 11 parts
To: 1 additive part

From: $355 per part to manufacture with traditional methods
To: $241 per part to manufacture with additive[1]

Simplify supply chain
Major tire company's tire mold

≤85% time-to-delivery reduction
≤20% mold cost reduction[2]

Create parts on-demand (MRO)
Cummins Inc.'s 3D-printed, low-volume bracket made in-house

From: 10 parts in inventory
To: 1 on-demand part with additive[3]

Reduce production lead time
Jung & Co. Gerätebau GmbH filler valve in a can-filling plant

From: 8–10 weeks to manufacture the stainless-steel part
To: 1 week with additive[4]

Enhance performance
MAPAL's new QTD-series drill insert combined additive cooling techniques with conventional manufacturing

From: 13 mm minimum diameter
To: 8–12 mm minimum diameter
100% increase in coolant flow
30% increase in flow quality[5]

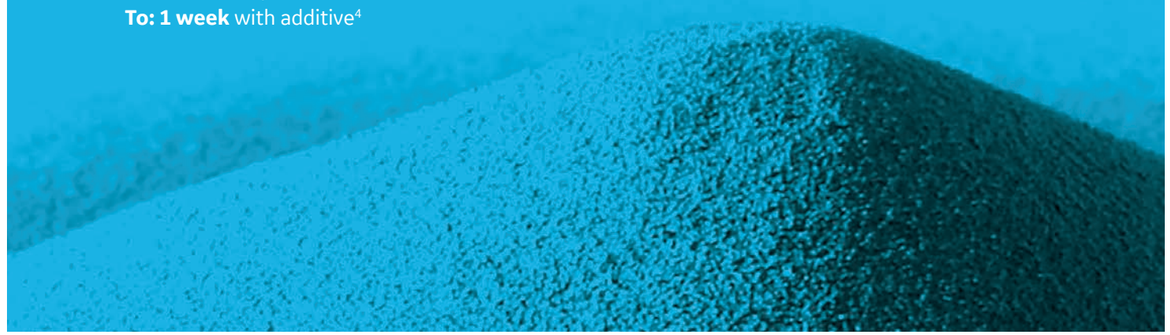
Reduce part warpage with added cooling channels
GPlast's music system deck for car audio players

Conventional cooling:
- 50 seconds
- 12% parts rejected
- 3.5 mm warpage

Conformal cooling:
- 20 seconds
- 3% parts rejected
- 0.5 mm warpage[6]

Reduce cycle time
Wild & Küpfer AG's mold insert for cover hood using additive parallel cooling technology

From: 21 seconds with conventional tooling
To: 14.5 seconds with additive[7]



OPPORTUNITIES FOR ADDITIVE

Conformal cooling

Strengthen your manufacturing processes with additive strategies that accelerate mold tool production, require less tool maintenance, facilitate faster cycle times and allow for smaller tool diameters.

Injection molding and die casting

AM allows for parallel and surface cooling channels to be designed and printed within the mold itself, which can reduce cooling time up to 30%,[8] thus reducing the overall cycle time. Balanced temperatures throughout the mold during the cool-down phase creates higher-quality parts due to less warpage and internal stress.

Tooling and cooling channels

Conformal cooling channels in tool production can lead to faster cycle times and improve the quality of the end-use part. For example, drills can leverage a mix of spiral and straight cooling channels to reduce tool maintenance and dead cavities and prevent boiling in the cooling channels.

Additive advantages of conformal cooling channels

Increase productivity

Cooling time in molding and casting averages 70% of the cycle time. Additive can reduce cooling time up to 30%, improving productivity and part quality.[9]

Build free-form cooling channels

Non-circular cooling channels (i.e., ellipticals, triangular and branches) enable rapid, uniform cooling process and minimize pressure loss.

Improve part quality

Minimize dead flow zones in cooling to prevent overheating of cooling water that can cause thermal shocks and heat cracks.

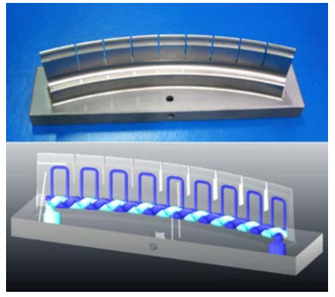
Reduce waste

Maintain a near and constant distance of the cooling channels from the mold insert to minimize defects from the heat transfer.

Optimize molding and casting with additive cooling technologies.

Design conformal cooling channels and features unmatched by machining. Surface and parallel cooling allows for improved temperature management and unique designs, such as spiral cooling ducts on the tool bodies and small-channel diameters.

Parallel cooling



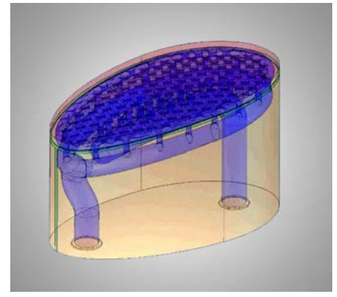
Small, unique cooling channels inside the mold of a bucket lid insert allow for parallel cooling of small geometries not possible with conventional cooling methods.

Results:[10]

Faster heat transfer due to short cooling channels with small diameters

Uniform cooling of material, maintaining equal properties throughout the mold

Surface cooling



Cooling channels form a mesh structure to enable uniform surface cooling of a glass insert for spectacles, just 2 to 3 mm beneath the mold contour.

Results:[11]

High-pressure stability throughout the part's arched structure

Even temperature control across large areas minimizes part distortion

Parallel and surface cooling

Once a limited and time-consuming cooling process, parallel and surface cooling strategies enable uniform cooling of the ejector pin's unique shape.

Results:[12]

Hot spot eliminated at the front end of the contoured pin with tiny cooling channels

Ideal heat transfer of large surface by cooling channels 0.6 to 0.8 mm from the mold contour

Maximum part strength due to helix-shaped, air-cooling channel within the pin

OPPORTUNITIES FOR ADDITIVE

AM for repair and restoration

Precise repair and restoration are critical in the maintenance repair and overhaul (MRO) industry as it ensures end-of-life products are returned to as-new condition. Traditional repair processes are manual and time-consuming.

Additive manufacturing allows for the repair and optimization of existing tools and parts, which leads to longer product lifetimes and saving costs. A combination process of traditional and additive manufacturing lets you additively build on top of a conventional, pre-manufactured part to create a hybrid part. That means you can capitalize on the low costs of conventional manufacturing as well as the design freedom and increased product functionality of additive.

Additive advantages for MRO:

Increase efficiency while maintaining quality

AM produces a near-net-shape tool, thus reducing the machining workflow steps, which leads to shorter throughput time in the MRO shop and saves time and costs—fewer production steps help reduce the risk for errors.

Save time and costs

Manufacturers can save significant time and costs by additively manufacturing parts on top of conventionally built base units.

Enable on-demand production

As a cost-effective method to repair and print parts, AM helps manufacturers achieve on-demand production and minimize downtime caused by broken parts.

OPPORTUNITIES FOR ADDITIVE

Supply chain robustness and resilience

Additive can help optimize manufacturing processes and streamline the larger supply chain. Shorten lead times and reduce costs by additively manufacturing hard-to-find and low-volume parts on-demand.

Additive advantages for supply chain efficiencies:

Reduce lead time

Manufacturers can print low-volume parts in-house, reducing the time to acquire replacement parts and streamlining the supply chain.

Lower expenditures

With parts printed on-demand, additive reduces production downtime and eliminates the expense of high-volume replacement parts.

Enable mass customization

Freedom of design with additive enables manufacturers to customize tooling for mass production of bespoke parts.

Extend product life span

With improved performance and less machining stress, additive extends the life span of outdated or damaged parts.

Streamline the supply chain

Additive enables more flexible inventory management, reducing inventory and the number of suppliers.

CASE STUDY

Cummins Inc.

When considering how additive could best impact its supply chain, Cummins Inc. focused on a low-volume bracket for a customer in its New and ReCon Parts division for which the customer did not have a current active supplier. By printing its bracket in-house, Cummins Inc. could now make the part on-demand, with less tooling and material waste than conventional methods.

Results:[13]

Eliminated part inventory with on-demand printing capabilities

Decreased tooling by eliminating material cutting

Cut non-recurring costs

Reduced lead time for low-volume parts

Streamline your supply chain. We're ready.

Challenge 1

Low-volume spare parts needed

Turn weeks of sourcing and repair into on-demand, supplier-free production. Manufacture low-volume, spare parts in-house with additive technology.

Challenge 2

Long lead times

The ability to manufacture a part for a replace-vs.-repair scenario has a direct impact on turnaround time. Leverage additive to reduce the risk associated with MRO and a diminishing supplier base, removing the burden of accessing and sourcing hard-to-find parts by printing them in-house.

Challenge 3

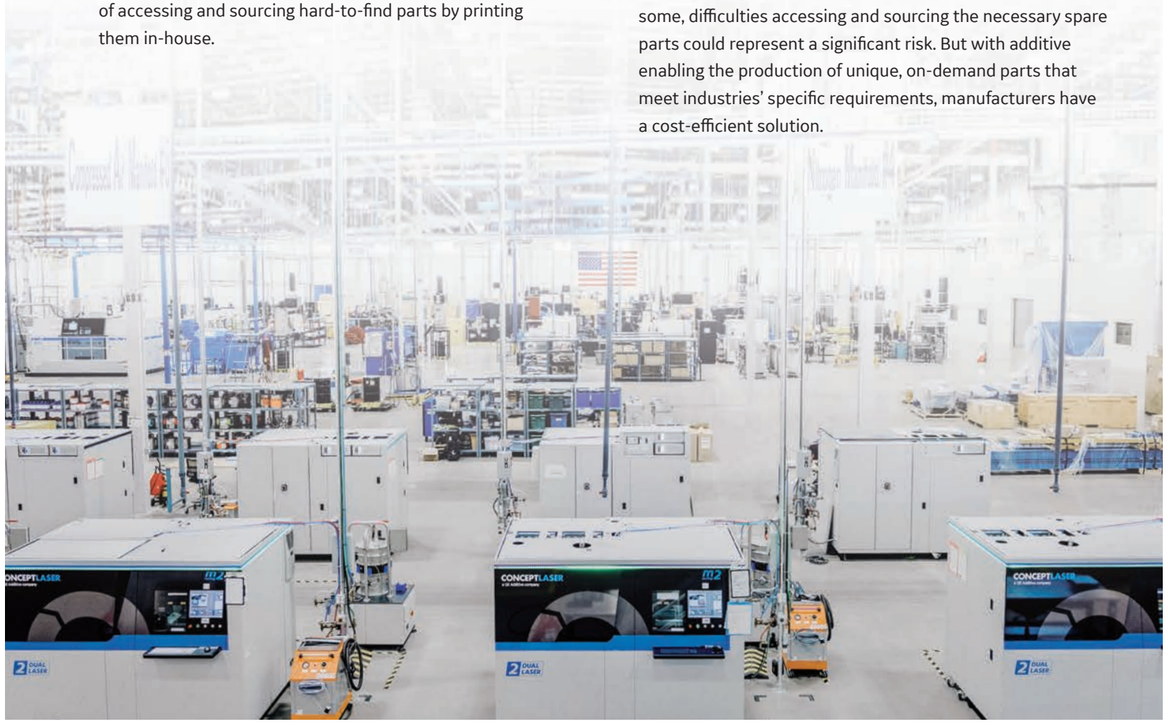
Too many suppliers and costs

"Complex" belongs in part design, not supply chain. Freedom of design empowers manufacturers to build unique structures, streamlining many parts from many suppliers into one additive part. The results are fewer purchase orders, less lead time and reduced costs.

Challenge 4

Sustainment and readiness of older equipment

Keeping aging equipment operational is no small feat. For some, difficulties accessing and sourcing the necessary spare parts could represent a significant risk. But with additive enabling the production of unique, on-demand parts that meet industries' specific requirements, manufacturers have a cost-efficient solution.



Highly alloyed tool steel

Known for its hardness and resistance to deformation, tool steel encompasses a wide variety of carbon and alloy steels well suited for tooling but challenging for additive—until now.

Electron beam melting (EBM) processes high-crack-prone alloys at high-build temperatures in a vacuum environment to yield complex designs—something neither conventional nor other additive methods can achieve.

Additive advantages for highly alloyed tool steel:

Lower cost per part

Additive with EBM machines maintains tight stacking of parts, reducing post-processing costs and lead time, and increasing productivity.

Create high-quality parts with excellent properties

EBM's high-heat process enables excellent hardness, wear-resistance and ductility, increasing the quality and lifetime of parts.

Leverage freedom of design

Consolidate parts into one additive product with complex geometries; part built is free-floating in sintered powder.

Arcam EBM Spectra H system

As the only commercially available EBM technology for highly alloyed tool steel and other crack-prone materials, the Spectra H system is the perfect match for these alloys. Its large build volume enables manufacturers to stack several parts per build, increases productivity and minimizes process steps in both product development and production.

CASE STUDY

Gear hob

GE manufactured a highly alloyed tool steel gear hob with additive EBM technology to minimize post-processing, save costs and improve wear resistance and ductility.

- Achieved high hardness of 62-63 Hardness Rockwell C (HRC)
- Built free-floating in sintered powder
- Manufactured in near-net shape

Pure copper

EBM enables previously unattainable applications of pure copper. Now, manufacturers can leverage the freedom of design with pure copper that combines several parts into one without compromising the high electrical and thermal conductivity. Achieve higher part performance at lower costs per component while avoiding soldering and welding.

Additive advantages for pure copper:

Enhance part performance

Parts maintain greater electrical and thermal conductivity and high ductility with pure copper components.

Reduce costs

Every weld or solder increases the cost of production. Additive can print the entire part.

Build complex geometries

EBM technologies allow for shape repeatability and unique structures, such as coils, tiny cooling channels and free-floating beams.

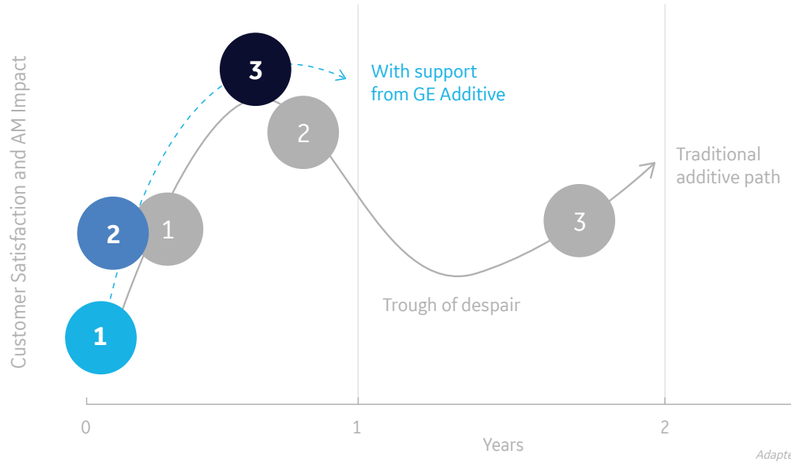
Applications for additive with pure copper:

	Benefits	Outcomes
Bus Bars **No more bending and welding.** EBM directly manufactures the whole product.	Parts maintain electrical conductivity and material homogeneity.	Achieve complex geometries at a competitive cost.
Heat Exchanger **New geometric capabilities** raise the component performance to a new level.	Pure copper provides excellent thermal conductivity and freedom of design.	Design complex shapes and thin cooling ducts with minimum distortion.
Inductor Coils **Reduce product costs associated with soldering several parts together.** EBM prints conductor coils as one part.	Pure copper delivers the highest electrical performance and longer life and reliability.	Increase part lifetime by combining parts into one build.

Additive parts at scale? We're ready.

Our proven process helps you adopt additive—faster.

Path to Production for Non-Critical Parts



Adapted from Gartner Hype Cycle

What are the Application Sprints?

Fast-track your path to full production of additive parts when you leverage the Application Sprints from GE's AddWorks™*.

Comprehensive support—workshops and training, hands-on consulting and print services—to accelerate time to market

Extra expertise where you need it, whether in concept, development, qualification or full production

Key process steps and GE's AddWorks Application Sprints:

Concept Application Sprint	Development Application Sprint	Production Application Sprint
1. Build a business case and identify a part.	2. Design the part for metal additive.	3. Qualify the part and enable full production.

Get there faster with a trusted partner.

For those manufacturing non-critical parts with metal additive, you can get to full production faster when working alongside someone who's done it before.

With support from GE Additive

- Work side by side with metal additive experts.
- Avoid missteps in creating a business case and selecting a part.
- Incorporate proven methodologies and best practices for additive design.
- Get access to GE's established material parameters and production tools.

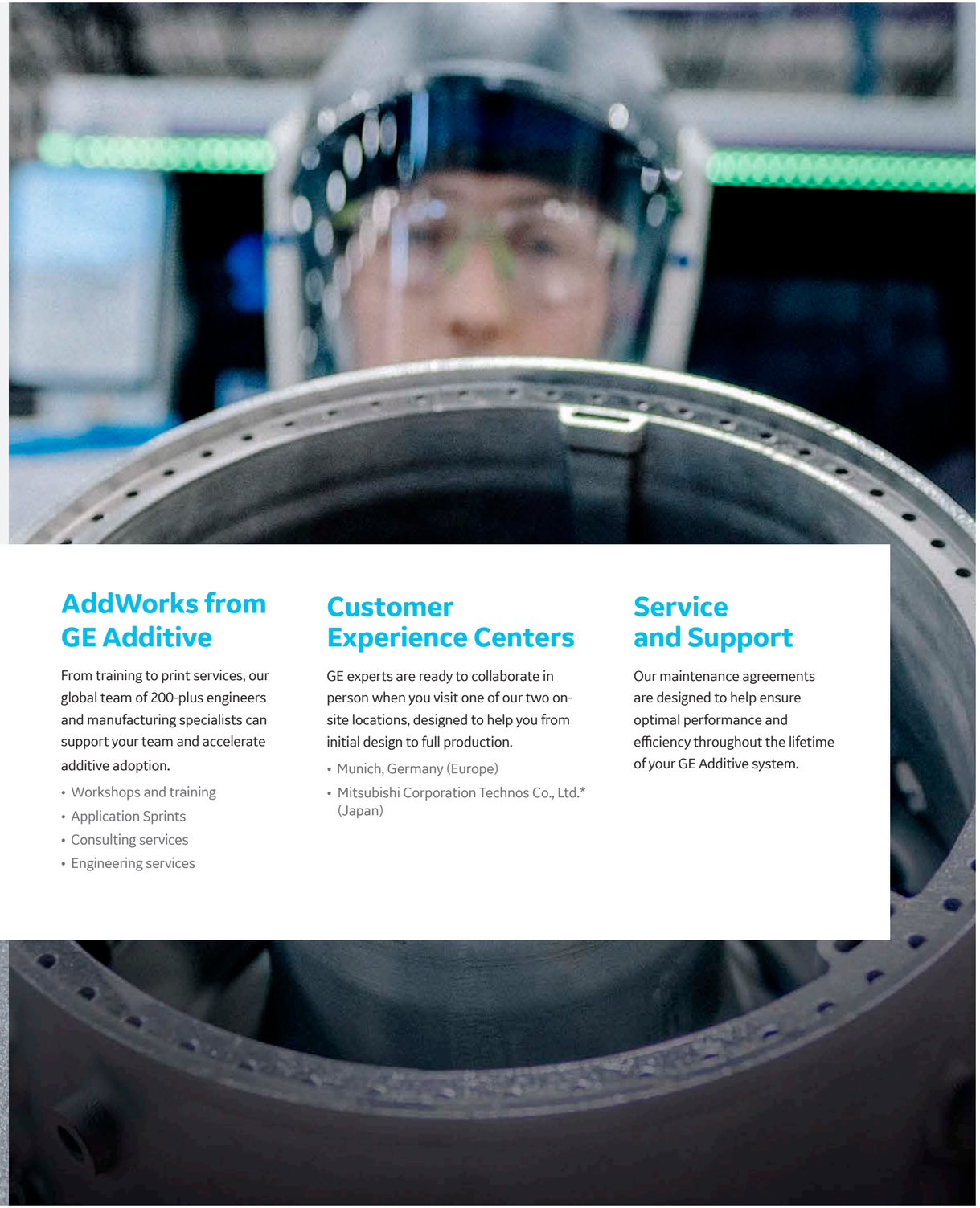
Without support

- Undergo a steep, long learning curve for your technical team.
- Risk your business case and part decision failing during development.
- Experience unanticipated expenses and obstacles.
- Go without existing best practices, templates or material parameters.

*Trademark of General Electric Company

GE Additive's end-to-end solutions, ready when you are.

See where our experts and offerings can support your company—from MRO and process improvements to making parts or molds with new metals.



Machines

Our specialty machines offer low machine-to-machine variance to meet your industry requirements and scale production.

- Concept Laser X Line 2000R (DMLM), enabling manufacturing of large additive parts with the largest build volume on the market
- Concept Laser M2 Series 5 (DMLM), enabling high productivity and quality
- Arcam EBM Q10plus, saving costs with high-precision structures
- Spectra H, high-heat, crack-prone materials

Powders

We create certified, high-performing powders for every metal additive need, taking into account a variety of mechanical behavior design data and material science.

- Titanium alloys
- Nickel alloys
- Aluminum alloys
- Cobalt chromium
- Stainless steels

Print Services

Ensure quality and speed to market when you send your part to GE for printing, no matter how complex or large the part. We serve you a printed part in one hand and a product roadmap in the other.

- Large-format printing
- Design to print (AddWorks)
- Production printing

AddWorks from GE Additive

From training to print services, our global team of 200-plus engineers and manufacturing specialists can support your team and accelerate additive adoption.

- Workshops and training
- Application Sprints
- Consulting services
- Engineering services

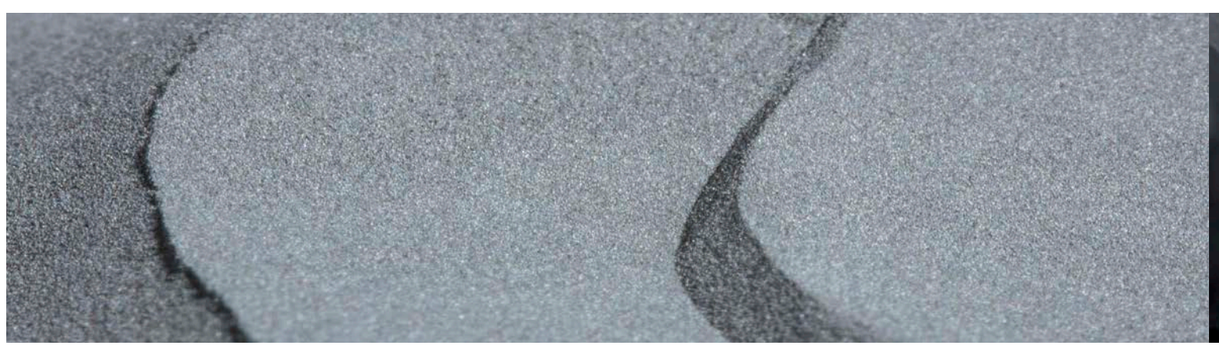
Customer Experience Centers

GE experts are ready to collaborate in person when you visit one of our two on-site locations, designed to help you from initial design to full production.

- Munich, Germany (Europe)
- Mitsubishi Corporation Technos Co., Ltd.* (Japan)

Service and Support

Our maintenance agreements are designed to help ensure optimal performance and efficiency throughout the lifetime of your GE Additive system.



*Sales partner in Japan

EBM AND LASER:

Which 3D printing technology is best for you?

Our experts will help you find the machine type fit for your application.

Key advantages

Electron Beam Melting (EBM) machines	Direct Metal Laser Melting (DMLM) machines
Design Freedom • Allow for dense nesting of entire build tank and large, bulky parts without swelling • Easily create little to no supports on parts at low costs **High Productivity** • Achieve high productivity for large volumes • High process temperatures produce parts with no residual stress **Cost-Effectiveness** • Enable use of reactive and crack-prone materials (e.g., TiAl) at low costs • Reuse powder extracted from the Powder Recovery Station (PRS)	**Design Freedom** • Allow for complex internal passages, thinner walled structures and undercuts • Create highly detailed and fine-feature parts directly from a CAD file **Surface Quality** • Achieve exceptional surface characteristics and minimal porosity • Deliver best-in-class repeatability, productivity and usability • Ability to print large, otherwise impossible parts safely, efficiently and consistently **Productivity and Safety** • Suited for highly regulated industries by providing superior part yield • Closed powder handling for less waste and operator exposure

Materials available for machines

Q10plus	Spectra H	M2 Series 5	X Line 2000R
			
• Arcam EBM Ti6Al4V Grade 5, P-Material • Arcam EBM Ti6Al4V Grade 23, P-Material • Arcam EBM CoCr, D-Material (Machine v1.0) • Arcam EBM Ti Grade 2, D-Material (Machine v1.0) • Arcam EBM Pure Copper, D-Material	• Arcam EBM TiAl, D-Material • Arcam EBM Nickel Alloy 718, D-Material • Arcam EBM Highly Alloyed Tool Steel, D-Material	• Stainless Steel 316L • Stainless Steel 17-4PH • Maraging Steel M300 • Aluminum AlSi10Mg • Aluminum AlSi7Mg • Nickel 718 • Nickel 625 • Titanium Ti6Al4V ELI Grade 23 • Cobalt CoCrMo	- Aluminum AlSi10Mg - Titanium Ti6Al4V Grade 23 - Nickel 718 - Cobalt CoCrMo

GE Additive

Are you ready?

To rethink mold making and die casting.

To accelerate production and shorten lead times.

To improve performance and reduce costs.

To look forward, not back.

When you're ready to optimize your business with metal additive, the people who pioneered its full production are ready to help.

Let's go. Talk to GE today.

ge.com/additive/industrial

[1]Tooling and Molding Precision Targeting EXTERNAL (accessed May 19, 2020).

[2]Tire Molds Precision Targeting EXTERNAL (accessed July 20, 2020).

[3]Blair Clafin, "Cummins Takes Next Step in 3D Printing and the Future of Manufacturing," Cummins, March 7, 2019, https://www.cummins.com/news/2019/03/07/cummins-takes-next-step-3d-printing-and-future-manufacturing (accessed June 11, 2020).

[4]The additive journey: The Time Is Now, Industry in 3D, (accessed May 14, 2020).

[5]David Sher, "MAPAL Mass Manufactures Drill to Perfection with 3D Printing," 3D Printing Industry, July 28, 2015, https://3dprintingindustry.com/news/3d-printing-serial-manufacturing-mapals-perfect-drills-say-yes-54254/ (accessed June 12, 2020).

[6]Gplast, 3D Cooling/Additive Manufacturing, http://www.gplast.com/3d-cooling-or-additive-manufacturing.php (accessed May 20, 2020).

[7]Tooling and Molding Precision Targeting EXTERNAL (accessed May 19, 2020).

[8]Tooling and Molding Precision Targeting EXTERNAL (accessed August 13, 2020).

[9]Tooling and Molding Precision Targeting EXTERNAL (accessed June 15, 2020).

[10]Tooling and Molding Precision Targeting EXTERNAL (accessed August 31, 2020).

[11]Tooling and Molding Precision Targeting EXTERNAL (accessed August 31, 2020).

[12]Tooling and Molding Precision Targeting EXTERNAL (accessed August 31, 2020).

[13]Blair Clafin, "Cummins Takes Next Step in 3D Printing and the Future of Manufacturing," Cummins, March 7, 2019, https://www.cummins.com/news/2019/03/07/cummins-takes-next-step-3d-printing-and-future-manufacturing (accessed June 11, 2020).