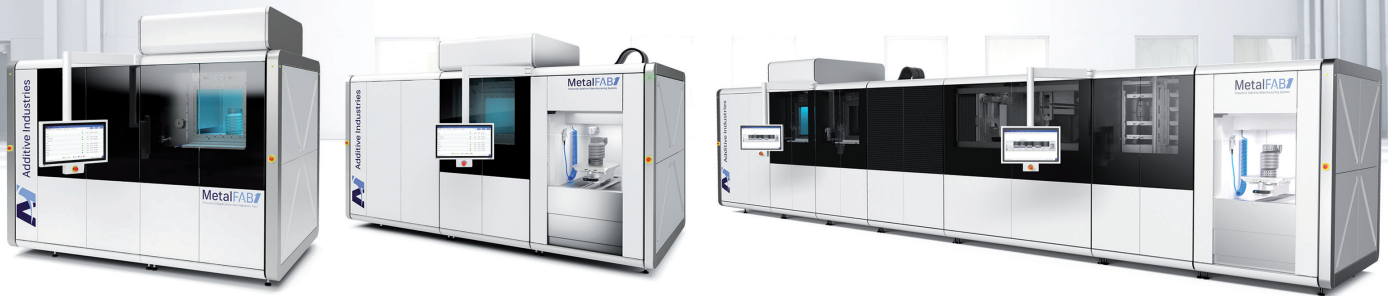


Accelerating

Industrial Additive Manufacturing





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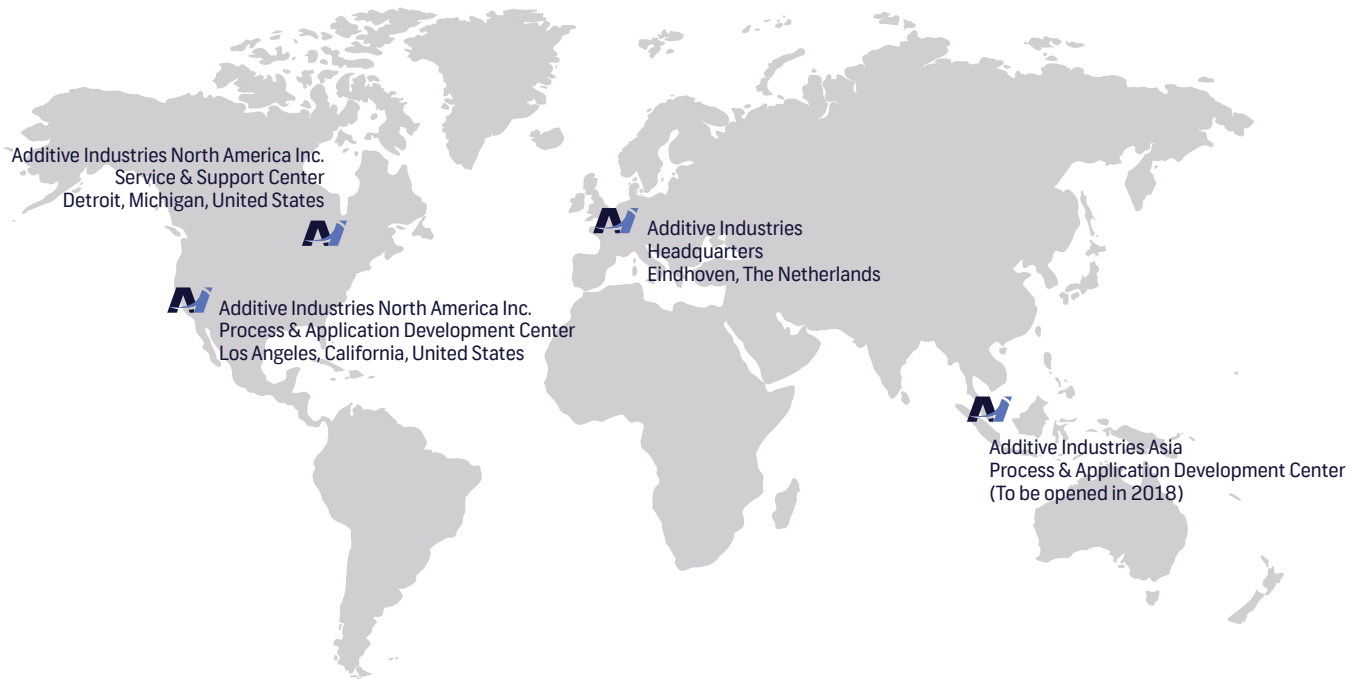
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Additive Industries

Established in 2012 in the “Brainport Ecostructure” around Eindhoven in The Netherlands, Additive Industries is the world’s first dedicated equipment manufacturer for industrial metal additive manufacturing systems. Built on the high tech systems, optics and electronics heritage of this region, founders Jonas Wintermans and Daan Kersten have created a company of talented professionals committed to industrialising 3D printing using ‘open innovation’ principles to capitalise on proven technology. By putting the customer first in everything we do, we enable them to improve their designs, product performance and business cases for the best competitive position in their market.

From its headquarters in The Netherlands, Additive Industries is building a global network to best serve local customers. Research & development and system integration as well as software development are done centrally in Eindhoven, while the activities closest to the customer are executed from regional Process & Application Development Centers and Service & Support hubs.



Additive Industries North America Inc.
Service & Support Center
Detroit, Michigan, United States



Additive Industries North America Inc.
Process & Application Development Center
Los Angeles, California, United States



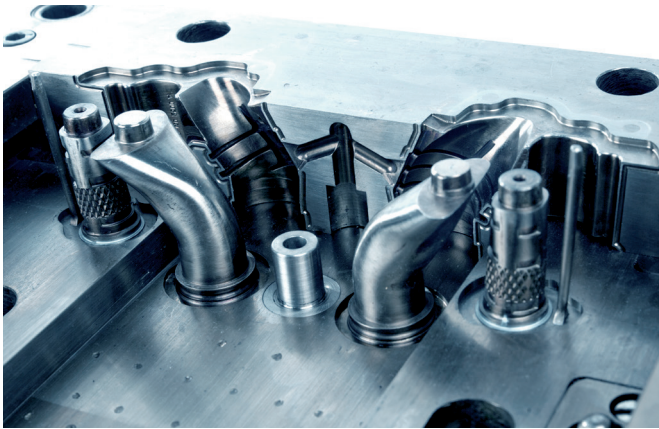
Additive Industries
Headquarters
Eindhoven, The Netherlands



Additive Industries Asia
Process & Application Development Center
(To be opened in 2018)

Accelerating Industrial Additive Manufacturing

Additive Industries is accelerating industrial additive manufacturing of high quality, functional, metal parts by offering a modular, end-to-end laser powder bed fusion system, MetalFAB1, and seamlessly integrated information platform, Additive World Platform, to high end and demanding industrial markets. With substantially improved reproducibility, productivity, and flexibility, Additive Industries redefines the business case for series production of additive manufacturing applications in aerospace, automotive, medical technology, tooling and high-tech equipment.





MetalFAB1

Industrial Additive Manufacturing System

MetalFAB1 is the first integrated metal additive manufacturing system designed for high end industrial applications in demanding markets like aerospace, medical, high tech equipment, tooling and automotive.

MetalFAB1 Family

Productivity leadership through integration and automation

MetalFAB1 was developed by a team of experienced high tech equipment engineers. Open innovation has led to a new and distinctive system architecture based on well-proven concepts and efficient application of matured functional building blocks from robotics, lithography and other opto-mechatronic systems.

For industrial-quality production with additive manufacturing technology, the reproducibility of the core powder bed fusion is assured by solid machine design in combination with advanced calibration technology and feedback control algorithms. Predictability is achieved by combining simulation and in-process quality monitoring with the additive manufacturing (AM) process. When a system is equipped with two or more additive

manufacturing core modules, productivity is up to ten times higher than typical midrange systems and multiple materials are possible without running the risk of cross-contamination.

For world class performance, operations in the metal additive manufacturing process flow need to work seamlessly together. Multiple process steps are combined in one machine using automated handling to reduce manual labour, improve product conformity and quality as well as increasing operator safety. The modular MetalFAB1 architecture ensures maximum flexibility and allows the user to define custom configurations from 3 to 11 modules and add additional lasers and optics as future productivity needs dictate.

MetalFAB1

Industrial Additive Manufacturing System

Industrial grade specifications

The MetalFAB1 system specifications are founded on a comprehensive system design process, defining the system architecture, modules, interfaces and controls to meet demanding customer requirements. An on-going dialogue with our customers feeds the technology roadmap for continuous improvement.



MetalFAB1 System Specifications*

Process type:	Metal Powder Bed Fusion
Net build envelope:	420 x 420 x 400 [mm] (16.5 x 16.5 x 15.7 [In])
Laser type:	Yb fibre laser, 500 [W] (future 1 [kW] possible)
Number of lasers:	1-4 (full field)
Process chamber O ₂ level:	< 100 [ppm]
Accuracy:	< +/- 0.050 + 0.0002 x Part Length [mm]
Part reproducibility:	< +/- 0.050 [mm] (3σ)
Optical calibrations:	In-line, automated, laser-2-laser
Layer thickness:	20-100 [μm]
Powder feed and handling:	Automated in each AM Core build chamber
Materials processing sets available:	Ti6Al4V, AlSi10Mg, Scalmalloy®, 1.4404 (AISI 316L), 1.2709, IN718
<i>(upon customer request new materials will be added, validation status may differ)</i>	
Maximum productivity (with 4 lasers, depending on material):	1.000 [dm ³ /year]
Minimum autonomous multi-job operation (maximum 8 build jobs):	112 [hrs]
Storage positions (single storage module):	Empty build plates: 8, Finished jobs: 2-8 (depending on build height)
Safety:	No direct powder exposure during regular operations
Job preparation:	Off line
Remote access & monitoring:	Yes, through Additive World Platform
In-process quality control:	PrintRite by Sigma Labs (optional)

* Specifications may change

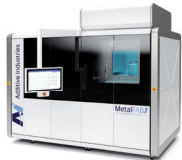
MetalFAB1

Industrial Additive Manufacturing System

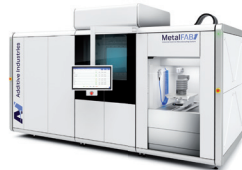
Configurations for various applications

Additive Industries offers a range of metal powder bed fusion systems based on application specific modular building blocks. The smallest footprint is a two module version developed specifically for process and application development and low-rate initial production. This configuration can be upgraded to a fully automated and integrated production additive manufacturing system with multiple materials, including post-processing functions such as heat treatment, part removal from the build plate and build plate storage. With up to four lasers that can scan the entire build platform and a build volume of 420 x 420 x 400 [mm], the MetalFAB1 system offers unmatched productivity.

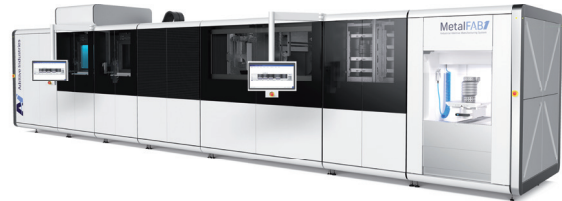
Process & Application
Development, Prototyping



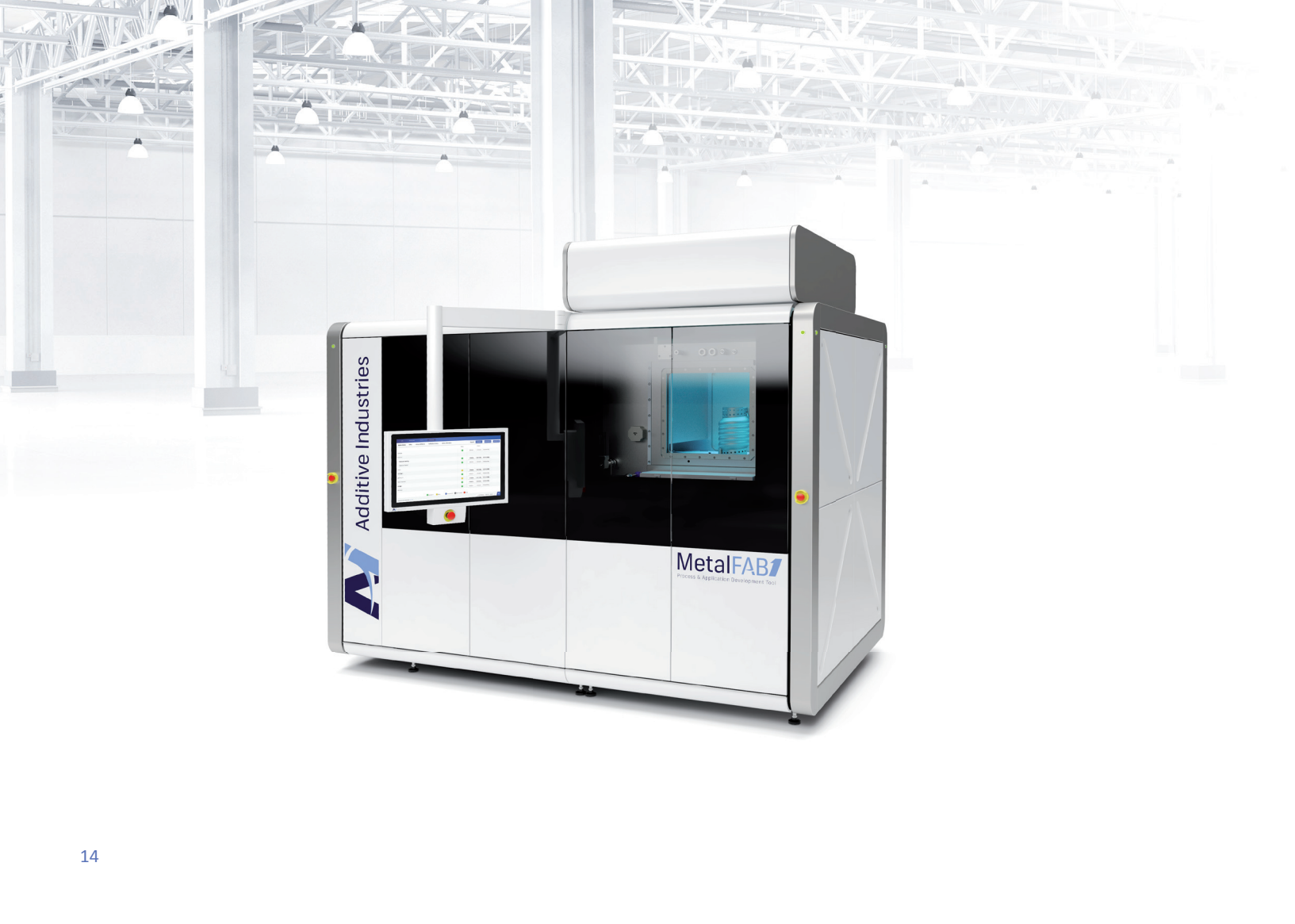
Small series
Full automation



Larger capacity, Multiple materials
Additional functionality



- > Build volume: 420 x 420 x 400 [mm], exchangeable
- > Lasers and optics: 1-4x 500 [W], all full field (1 [kW] 2018 H1)
- > Calibration strategies: focus, X-Y, laser-2-laser
- > Future proof: open platform, upgradable, modular expandable



Additive Industries



MetalFAB7
process & Application Development Tool

MetalFAB1

Industrial Additive Manufacturing System

Process & Application Development Tool

The smallest footprint and, therefore, most lowest cost member of the MetalFAB1 family is the Process & Application Development tool. It is designed specifically for new users of the metal additive manufacturing technology, as well as experienced process & application development departments and prototyping use. Although it is configured with two modules (see section 'MetalFAB1 Modules explained' for full description of the modules and its functionality), it has most MetalFAB1 powder bed fusion features and functionality like 420 x 420 x 400 [mm] build volume, 1-4 full field lasers and fully automated powder handling and extraction (in continuous inert conditions for limited material degradation).

The modular architecture of the MetalFAB1 makes the Process & Application Development tool a future-proof investment since it can be upgraded to improve productivity later with additional lasers, more material types (extra AM Core Modules) and additional functional modules for process automation and reduced powder exposure (Exchange Module, Storage Module)

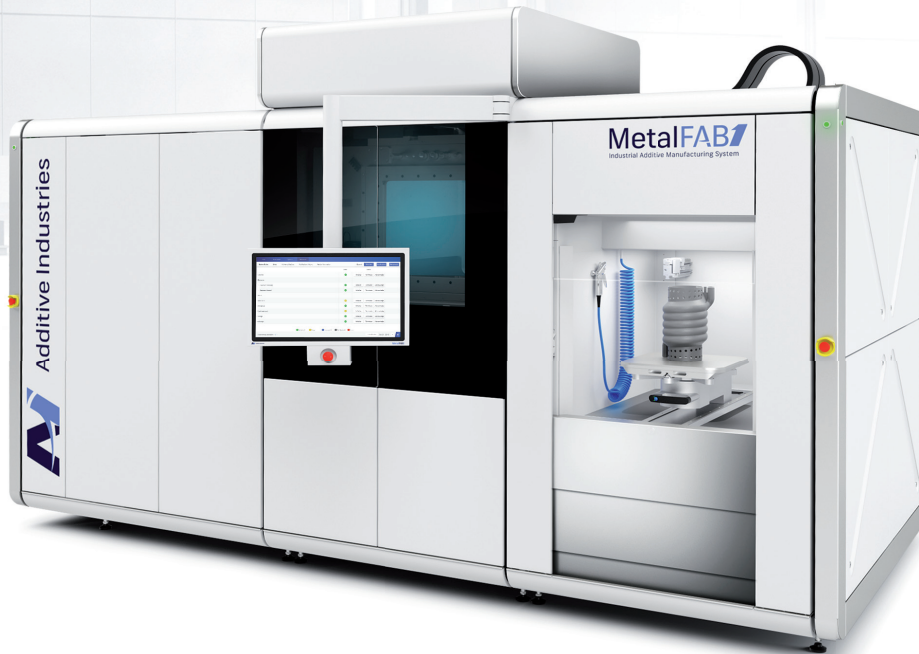
as well as post processing (Heat Treatment, Product Removal Module). Since the powder bed fusion process doesn't change with upgrades, part and process qualification is easier as production scales up.

Typical use:

- Process and application development
- Part qualification
- Low rate initial production

Configuration:

- Controls Module
- Additive Manufacturing Core (AM Core)
- Exposure Module (1 laser, can be upgraded to 2, 3 or 4 lasers)
- Human Machine Interface (HMI)



MetalFAB1

Industrial Additive Manufacturing System

Basic

The entry-level production version of the MetalFAB1 family is the MetalFAB1 Basic. This three module powder bed fusion system is developed for fully automated and safe production of single large parts or small series production. The Exchange Module and Robot automate all build plate and finished product handling, thus eliminating operator labour and preventing direct contact with metal powders during regular production. Moreover, system and laser calibration can be done automatically between build jobs for the highest reproducibility and productivity.

The MetalFAB1 Basic also can be equipped with additional lasers for faster production rates of large parts, a second AM Core Module for increased productivity, extra modules for new materials (AM Core Modules) and post-processing (Storage, Heat Treatment and Product Removal).

Typical use:

- Single part production
- Small and mixed series production
- Large parts (in 420 x 420 x 400 [mm] or 16.5 x 16.5 x 15.7 [In] build volume)

Configuration:

- Controls Module
- Additive Manufacturing Core (AM Core)
- Exposure Module (1-4 lasers)
- Human Machine Interface (HMI)
- Robot
- Exchange Module



MetalFAB1

Industrial Additive Manufacturing System

Productivity

Starting with a MetalFAB1 Basic (see description on previous page), the MetalFAB1 can be extended to a fully integrated high productivity metal additive manufacturing system. The MetalFAB1 Productivity is configured to the typical component the user will manufacture. For the lowest total cost per part, the MetalFAB1 Productivity contains four lasers and at least two Additive Manufacturing Cores for continuous printing. While in one AM Core a job is being executed, the other can be used for automated powder extraction, build plate exchange, inerting as well as (preventive) maintenance. This increases the manufacturing time and efficiency of the system. Integration of thermal post processing and product removal increases the reproducibility, reduces manual labour, in addition to removing the need for separate equipment. Process qualification is also made easier with integrated heat treatment. The Storage Module, which holds up to eight new build plates, allows the system to be operated 24/7 with only a single shift since the system can automatically start a new build job from the build queue.

The exact configuration of the MetalFAB1 Basic is based on a detailed calculation of the total cost and a comprehensive business case by the Additive Industries Process & Applications Development team.

Typical use:

- Mixed material small batch manufacturing
- Production of various part families
- Larger series of small and medium size single material parts

Configuration:

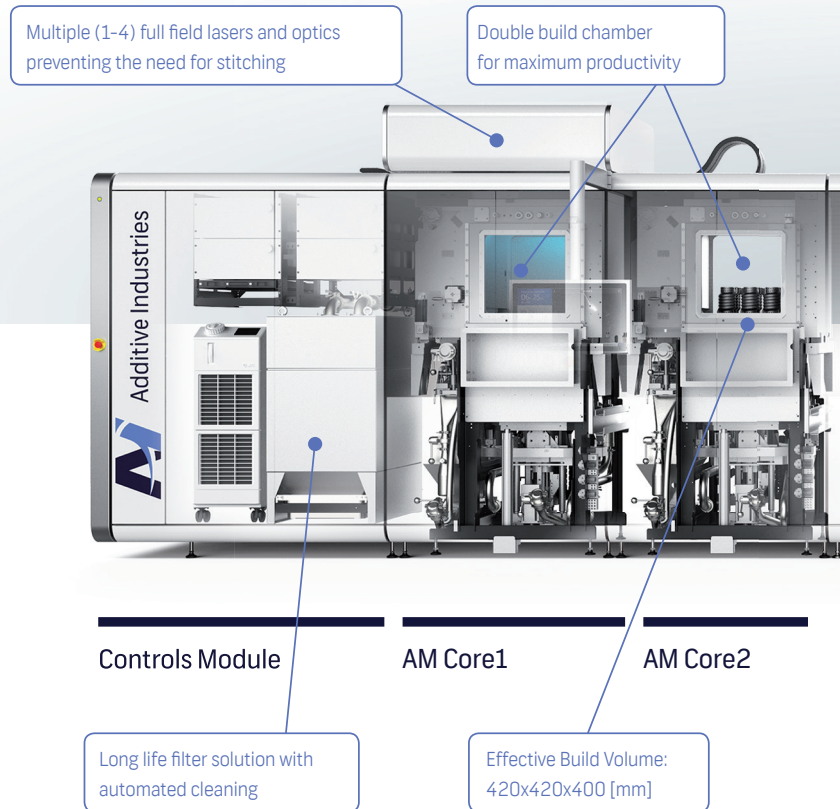
- Controls Module
- 2-4 Additive Manufacturing Cores (AM Core)
- Exposure Module (1-4 lasers)
- Heat Treatment Module
- Product Removal Module (for removal of parts and resurfacing of build plates for instant re-use)
- Storage Module (for 8 new build plates or 2-8 finished build plates)
- Dual Human Machine Interface (HMI)
- Robot
- Exchange Module

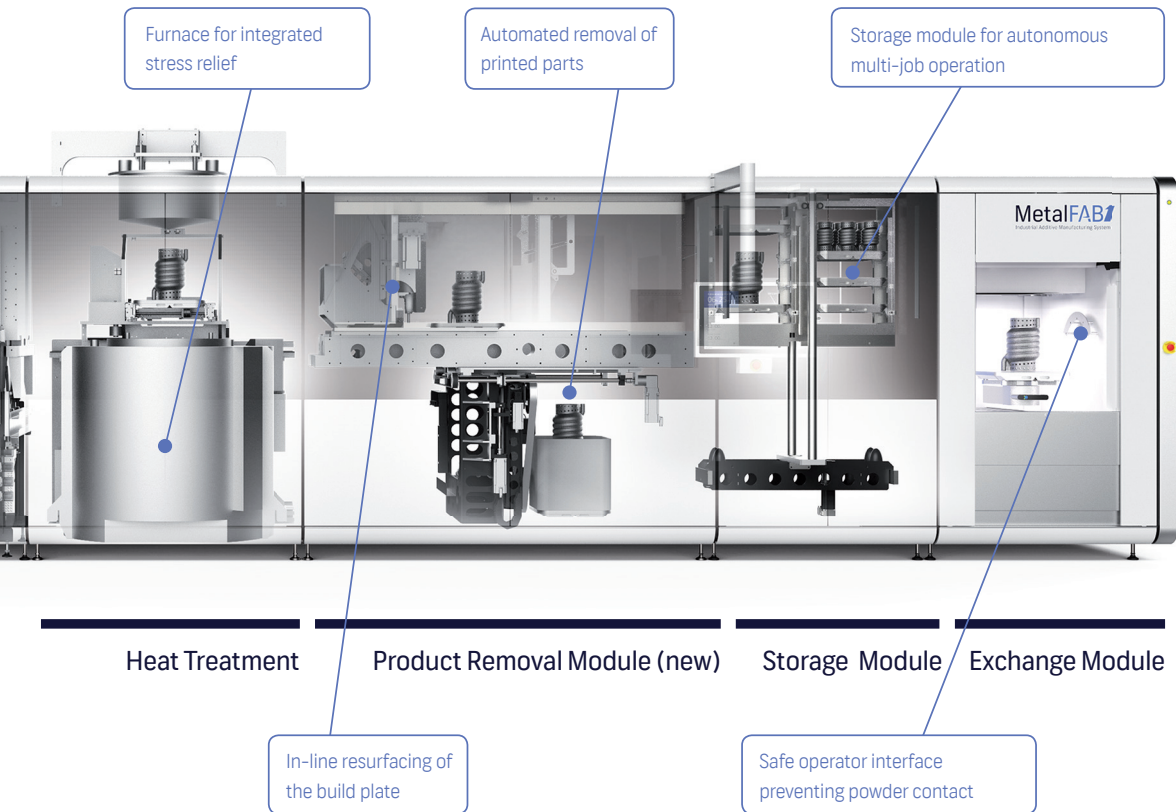
MetalFAB1

Industrial Additive Manufacturing System

Modules explained

The MetalFAB1 metal additive manufacturing system is a modular design that allows our customers to configure their system to fit their applications, tune the system to the required productivity and to match the scope of process steps required for integration. Moreover, it allows Additive Industries to continuously improve the MetalFAB1 Family by adding functionality and upgrading modules. This substantially extends the service life of the MetalFAB1 system and virtually eliminates the risk of obsolescence. The following section contains a detailed explanation of each module.





Controls Module

The Controls Module provides the process necessities (excluding metal powders) for the MetalFAB1 system and houses a number of main components for safe operation:

- Electrical cabinet and mains connection
- System Control hardware
- Process gas supply and conditioning
- Transport gas supply and conditioning
- Cooling water chiller (water to water heat exchanger)
- Long life filter based on chalk coating technology to neutralise reactive powder particles
- Laser bays (1-4)

Main Characteristics

- Low consumption of inert gas (Argon or Nitrogen)
- < 100 ppm O₂ management for safety and process quality



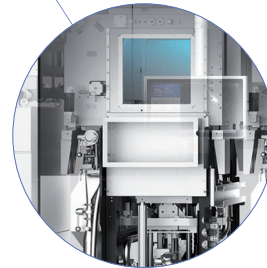
Additive Manufacturing Core Module (AM Core)

The AM Core Module is the heart of the MetalFAB1 system and together with the Exposure Module (see next page) the AM Core produces parts using laser powder bed fusion Additive Manufacturing with a maximum of four 500 [W] or 1 [kW] lasers. It is the core production module of the MetalFAB1 system and consists of the following sub-modules:

- Build chamber with heated platform
- Recoater arm, bidirectional for adding powder each direction
- Powder handling system for loading powder, powder extraction (cleaning the powder from the products) and full powder recycling

Main Characteristics

- Net build envelope: 420 x 420 x 400 [mm] (x-y-z)
- Build plate heating for elevated production temperature up to 200 [°C] for powder pre-heating
- Automated build plate levelling
- Fully automated powder extraction and recycling system
- Continuously monitored inert atmosphere for powder material during operation and storage



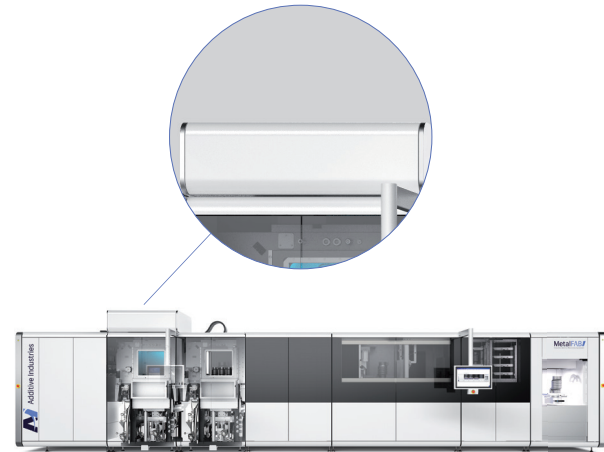
Exposure Module

The Exposure Module works with the AM Core to provide the thermal energy necessary to melt the metal powder and is the optical heart of the system and consists of the following sub-modules:

- Laser(s)
- Beam deflection and focus system(s)
- Full build platform area coverage for all lasers
- Optical metrology and calibration system

Main Characteristics

- 500 [W] or 1 [kW], 1070 [nm] Yb fibre laser in 1, 2, 3 and 4 laser versions
- 420 [mm] square full field vector scanning capability
- Adjustable focus
- Automated self-calibration



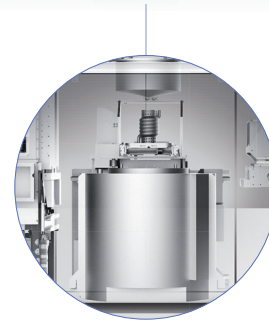
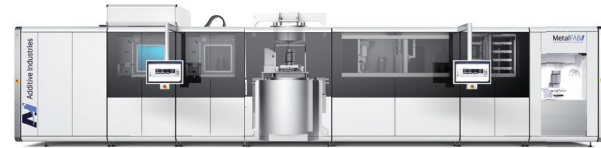
Heat Treatment Module

The Heat Treatment Module provides thermal post-processing in a controlled temperature profile/cycle to stress relieve parts attached to the build plates in order to prevent geometric distortion. Oxidation and nitride formation are prevented during the heat treatment cycle through the use of an inert gas atmosphere.

No operator interaction is necessary to initiate heat treatment as transport of build plates with parts is controlled by the handling robot with automatic door actuation and locking. The heat treatment sequence is part of the job recipe and therefore executed consistently, adding to the reproducibility of the total process. Integration of heat treatment also simplifies part and process qualification for regulated industries like aerospace components and medical products.

Main Characteristics

- 420 x 420 x 500 [mm] maximum part dimensions (including build plate)
- Up to 1100 [°C] temperature range with programmable cycle times
- Fully sealed inert atmosphere (< 100 ppm O₂ management for safety and process quality)



Product Removal Module

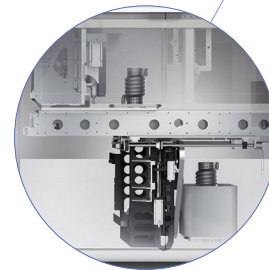
The latest addition to the MetalFAB1 Family is the Product Removal Module. This module allows for integrated removal of printed parts from the build plate, after heat treatment, The same module also provides resurfacing of the build plate without any operator intervention. This creates a shorter turnaround time for build plates to return to production and, therefore, reduces the investment in the number of build plates required in a production environment and the logistics associated with material handling. Also, the quality of the build plate resurfacing is more consistent and the powder bed fusion department has more control over production supplies.

The module consists of the following sub-modules:

- Trapped powder removal (in supports or channels)
- Product removal with band-saw technology
- Surface milling with integrated tool changer
- Products collected in separate bin for safe transport
- Atex grade vacuum cleaner

Main Characteristics

- Maximum product dimensions 404 x 404 x 400 [mm], R52 mm (bin restrictions)
- Minimal 6 build plates separated and resurfaced per 24 [Hrs]
- Automatic build plate thickness measurement
- Suitable for machining various materials in random order
- Collision detection on milling spindle to prevent damaging of parts

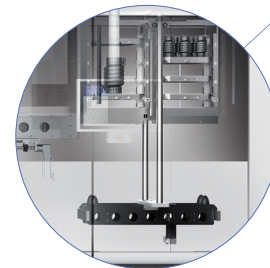


Storage Module

Build plates with and without parts printed on them are housed in the Storage Module waiting for further processing or unloading from the system. This module enables the system to operate more autonomously with little or no operator interventions. Multiple build jobs can be executed autonomously for extended periods up to a minimum of 112 [hrs].

Main Characteristics

- Storage capacity of 8 empty build plates and as many products and build plates as possible within volume
- Design suitable for different product heights (up to 400 [mm])
- Storage module easily supports one shift operation

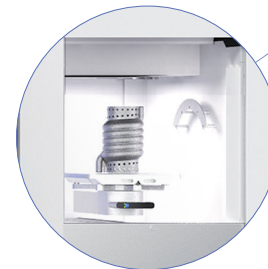


Exchange Module & Handling Robot

The Exchange Module provides the interface between the system and the operator. The module provides a loading/unloading platform to load empty build plates or unload finished build jobs.

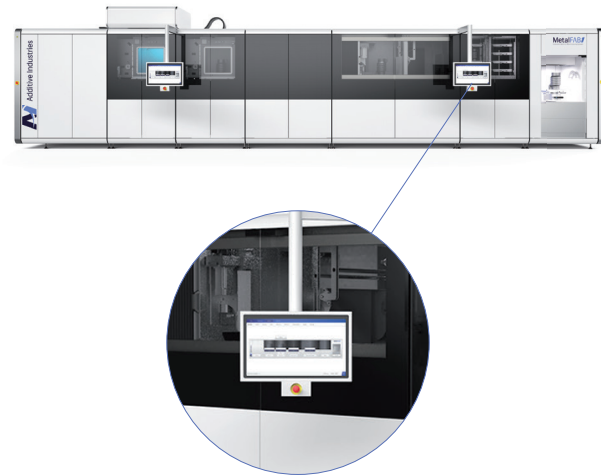
The Exchange Module can be easily and safely accessed with the Additive Industries Build Plate Handling Tool, a forklift or handling crane from the outside. A vacuum cleaner is integrated in the exchange module for easy and safe removal of any residual powder in support structures or trapped powder in channels.

The Exchange Module also stores the two calibration plates for automatic calibration between two jobs. Combined with the Handling Robot, the Exchange Module arranges full automated transport of the empty build plates or finished products between the individual modules such as AM Core(s), Heat Treatment, Product Removal and Storage.



Human Machine Interface (HMI)

The HMI is the main point of interaction between the operator and the system. All relevant information is displayed and via a large touchscreen monitor, the operator can interact with the actual build process or manage planned and finished build jobs. User centred and intuitive software design supports easy operation and provides unambiguous user interaction.



Our MetalFAB1 system is fully integrated with the Additive World Platform, which supports the end-to-end 3D metal printing workflow. It allows our customers to store, share and analyse all relevant data in order to learn and improve quickly, and meet the high standards of regulated markets.

The Additive World Platform is developed with the purpose to support the AM process in all its facets, from design to manufacturing, from post-processing to machine integration and

testing, supported by a central knowledge management and (big) data solution. The Additive World Platform comprises of different components and applications that include: support for remote management of the Additive Manufacturing workflow, specific support for job preparation, machine and equipment monitoring, maintenance login and (big) data gathering and analytics. All with the purpose to support a controlled and stable manufacturing process, with continuous improvement of uptime and process quality to lower the cost per part.

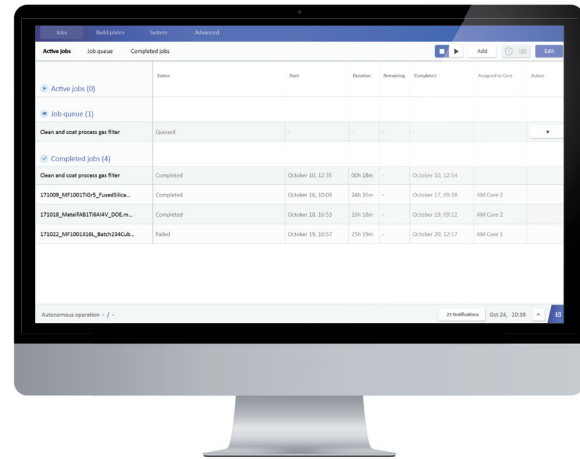


The platform offers a number of functions and integrated third-party applications to support the core additive manufacturing process, including the following:

Design and Simulation

Apart from the workflow to support the management of part optimisation, the Additive World Platform offers the functionality to store all relevant part data in a single place, including CAD and CAM data – all governed under version control that manages version history and is used to link part versions to production builds, allowing a full part history overview in the system.

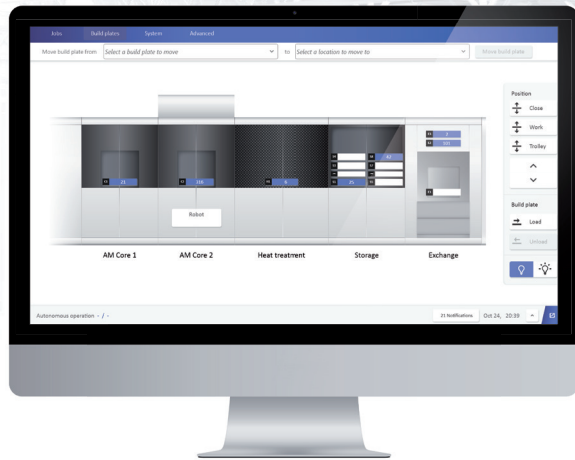
By integrating 3DSIM's exaSIM package (optional), the Additive World Platform will offer integrated part as well as build simulation. This will enable users to prevent build failures by predicting errors in simulation



as well as improving part design and build support in order to reduce the risk of build errors all while increasing functionality.

Work Preparation

The planning and preparation module includes functionality to support the sales process (next to existing ERP systems), cost price calculation, additional functionality on existing job preparation packages as well as insight into machine planning/occupation and production queues. Standard open interfaces are being developed to allow the platform to work on top of existing systems, enhancing productivity by integrating with 3rd party systems and processes.



Print Process Management and Quality Control

The print process management functionality supports the workflow of combining scheduled parts into builds and defining the build recipe based on part parameters, while storing all relevant data in a single repository throughout the build process. This allows full visibility of job history, storage of relevant quality control data and job reporting. Furthermore, it supports the scheduling of builds (in the future with real-time synchronisation with MetalFAB1 system) distributed across different locations, machines, build plates and materials, and enforces checklists for machine operation, all while continuing to store all relevant data.

Post Processing

Similar to the processing of 3D printed parts, the platform offers full scheduling and tracking functionality for user-defined post-processing steps. Not only for managing the different post-processing steps, but also for recording a full history of produced parts.

Process & Application Development

Additive Industries' skilled and experienced Design for AM professionals will give the customers high quality support in design, application and business case development. They are also happy to provide training in Design for AM as well as assessment of customer parts for suitability of manufacture in AM.

Application Development

Our Application Development team will help you to transform your idea to series production. Integrated industrial Additive Manufacturing enables product customization and eliminates the need for complex logistic chains. By assessing all aspects of your value chain, product application and manufacturing volume we will jointly specify product requirements for the MetalFAB1 system configuration and help reshape your supply chain.

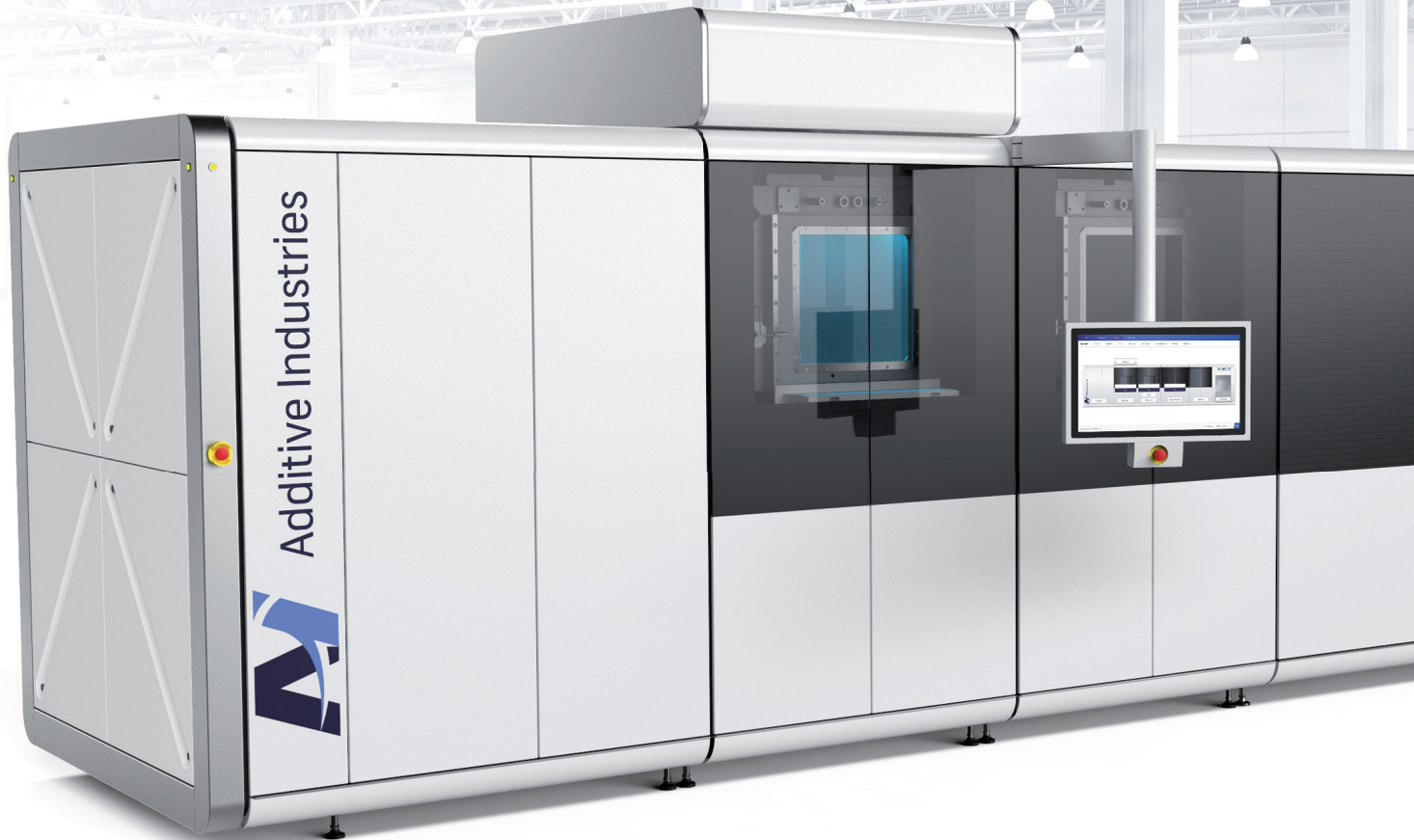
Material & Process Development

To ensure a seamless introduction of new materials and processes, Additive Industries supports you in selecting materials, developing and validating optimal build process settings and post-processing options. Process predictability and part quality will be assured and unexpected build process behaviour will be prevented.

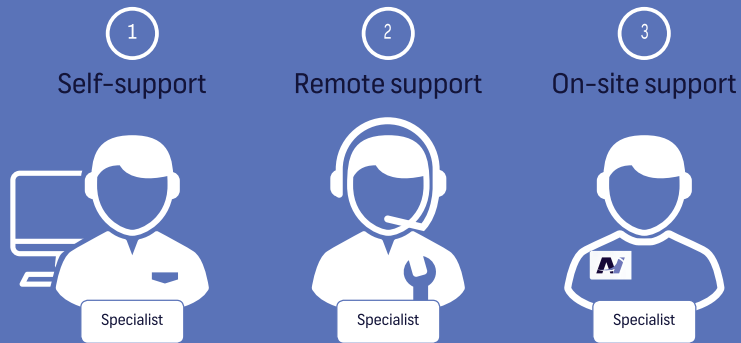
Qualified powder characteristics are fundamental for predictable and repeatable product quality. Additive Industries offers a range of material qualification and validation services, assuring the constant supply of qualified powder.

Customized Module Development

With customized modules the functionality of MetalFAB1 can be tailored to your process flow in order to increase flexibility and productivity. For example, future modules can offer part separation or surface treatment processes to create a fully integrated industrial grade production system. Closely cooperating with our customers we will define, develop and manufacture customized modules to increase the MetalFAB1 system flexibility and extend your system's lifetime.



3-Stage support



Comprehensive toolkit



Customer Lifecycle Support

After a successful MetalFAB1 system installation at the customer's site, Additive Industries provides onsite classroom and hands-on training to transform our customers into skilled professionals in operating and maintaining our systems. Additive Industries' highly skilled and experienced Customer Lifecycle Support team will help train our customers to maximize the system manufacturing uptime through immediate hotline response times, online live video monitoring (MyRemoteCoach), remote training, and via fast

delivery of spare parts and consumables. We employ state-of-the-art technology and tools to continuously monitor system health in order to optimize system availability and uptime, to minimize (remote) diagnostic time and to allow for remote equipment and software maintenance. When the situation demands, Additive Industries stands ready to offer customers our on-site support and maintenance services to ensure that the highest possible uptimes are achieved.

Contact details

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