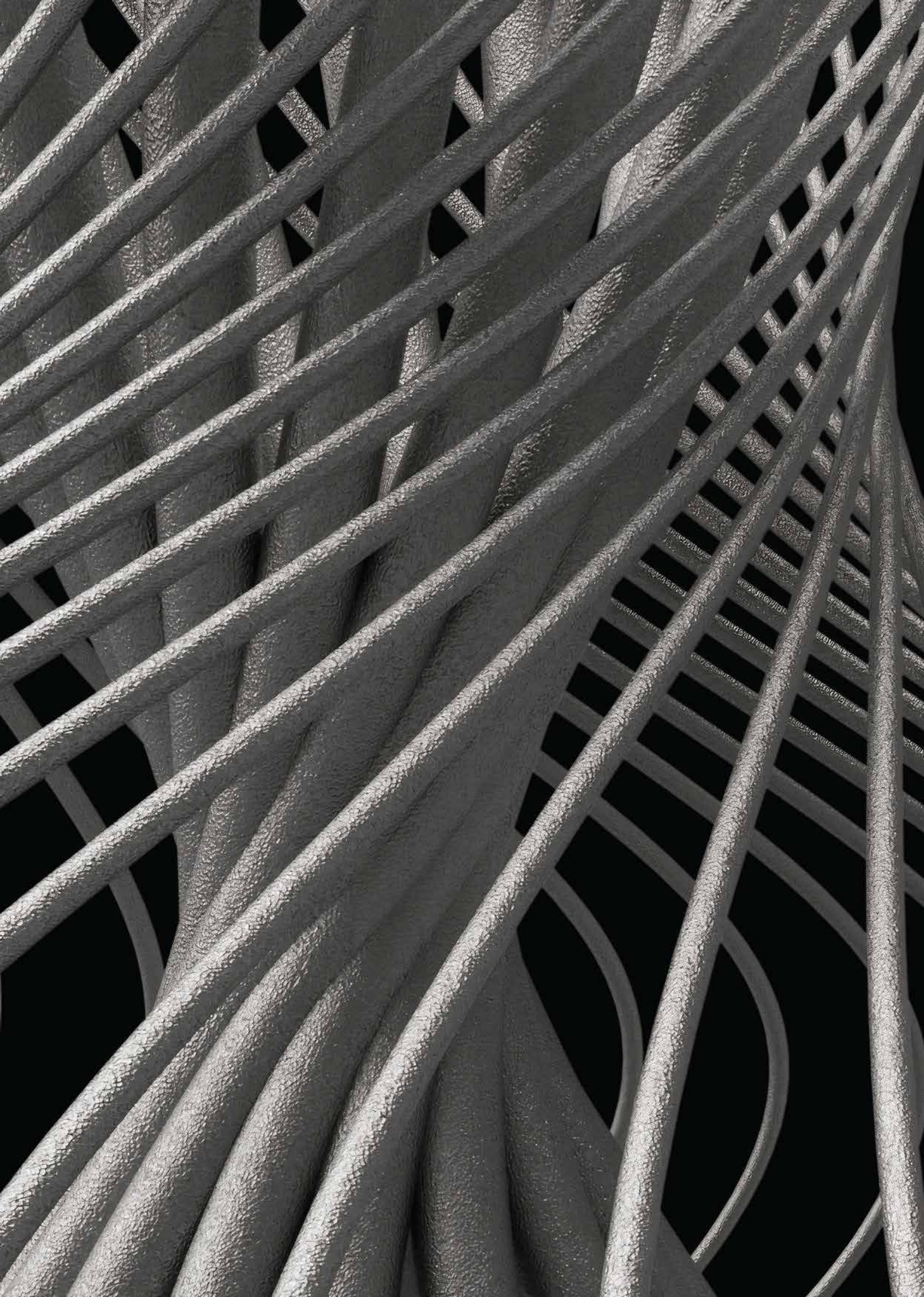
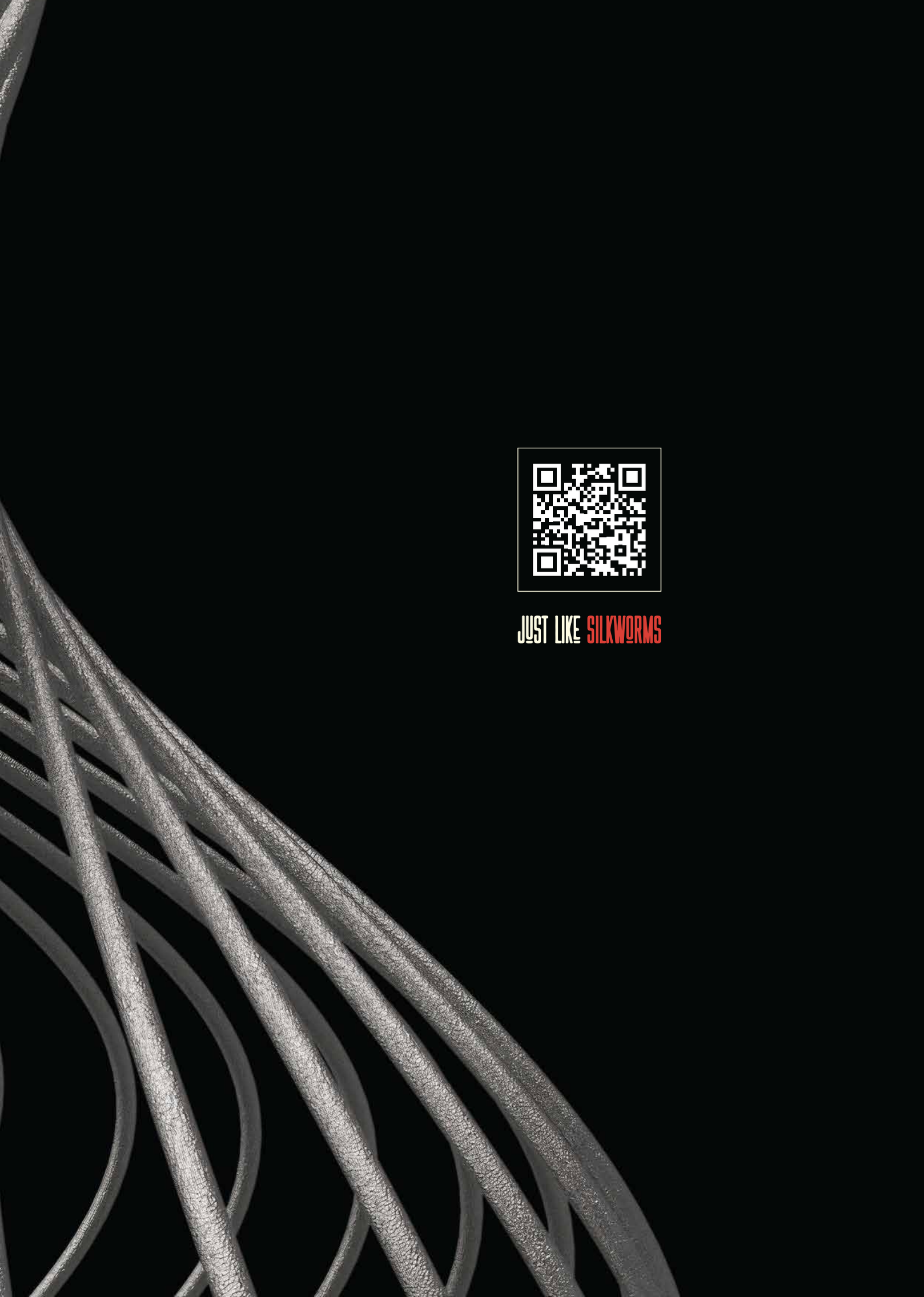
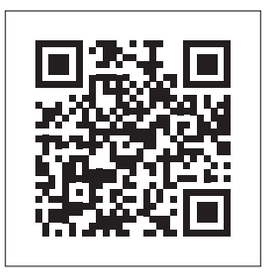
METALWORM

Cutting Edge Technologies on
Robotic Additive Manufacturing




JUST LIKE SILKWORMS



JUST LIKE SILKWORMS

Teknopark Ankara,
2224. Cad. No:1
B Blok Zemin Kat,
06378, İvedik Osb
Yenimahalle
Ankara/TÜRKİYE

# TABLE OF CONTENT

## MetalWorm Brand Story

The inspiration of the METALWORM brand is “Silkworms”. Like silkworms weave silk and stack fibers, METALWORM weaves metal and stack molten metal.

The trademark METALWORM has been associated with the additive manufacturing process in cutting-edge manufacturing technologies, which shortens production time and minimizes the amount of raw materials.

## Mission

At MetalWorm, our focus is on computer-controlled robotic additive manufacturing technologies. We aim to provide solutions that best meet our clients' needs, with a particular emphasis on the Electric Arc method, which falls under the Direct Energy Deposition (DED) methods.

## Vision

Our goal is to offer an additive manufacturing system that decreases processing durations and costs across various sectors, including aerospace, energy, rail systems, construction and shipbuilding.
Metalworm envisions a future where their cutting-edge technology not only revolutionizes the manufacturing industry but also significantly reduces the carbon footprint by minimizing waste and energy consumption in the production process.

# MetalWorm Milestone

**2015**

First WAAM trials with Robotic CMT

**2017**

First scientific results published

**2018**

Preliminary WAAM workshop tests done with industrial partner

**2019**

WAAM works presented in International Conferences

**2020**

WAAM Technology Development Research Project was supported by TUBITAK

**2021**

Latest WAAM technology findings presented in International Conferences

**2022**

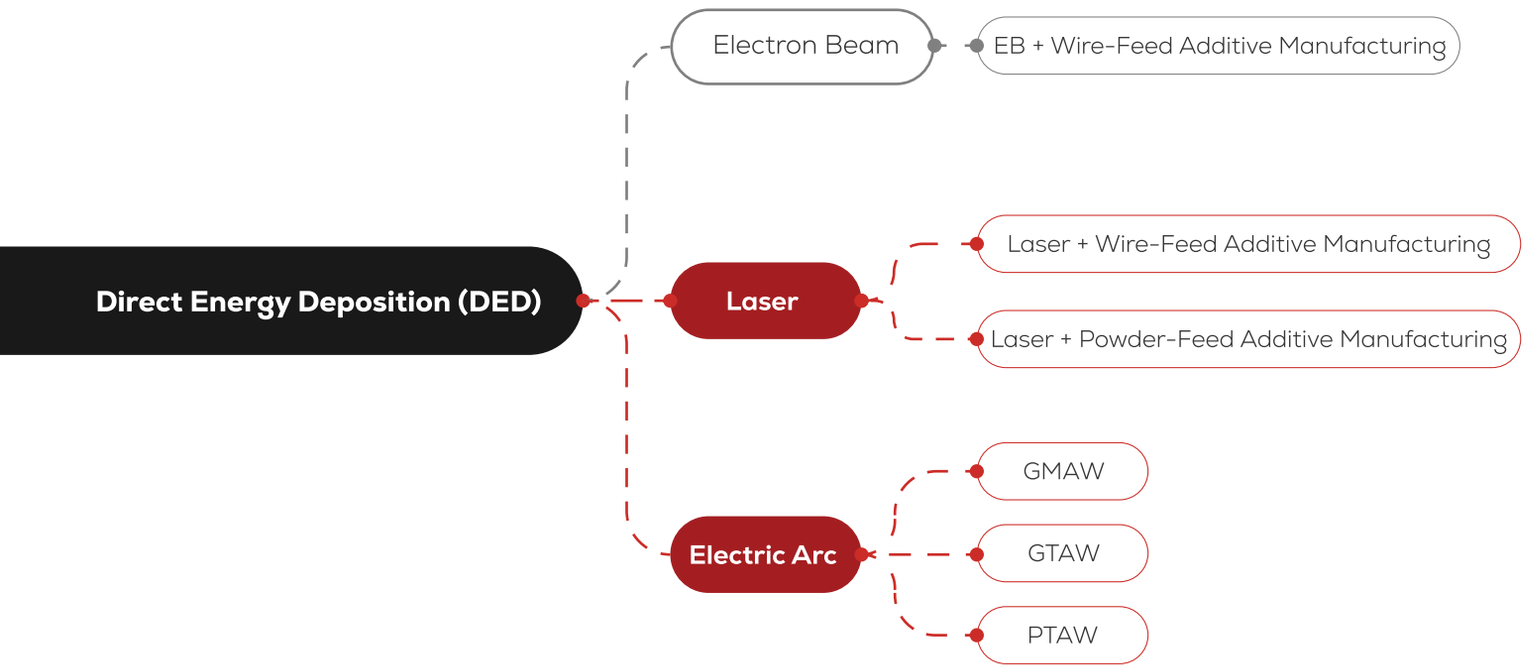
The launch of a commercial Robotic WAAM System MetalWorm in Formnext 2022 and MetalWorm Inc was founded in December 2022 as a spin-off company of Intecro Robotics.

# ROBOTIC ADDITIVE MANUFACTURING TECHNOLOGIES

WAAM (Wire Arc Additive Manufacturing)
Laser DED (Laser Directed Energy Deposition)

**TAILOR MADE, TURNKEY**
SYSTEMS

# Print Techniques




# Waam Advantages

WAAM (Electric Arc) - Based

## Gas Metal Arc Welding (GMAW)-based

- Uses a consumable wire electrode
- Suitable for various metals and alloys
- Excellent material deposition rate
- Good for large-scale part production
- Low material waste

## Gas Tungsten Arc Welding (GTAW)-based

- Uses a non-consumable tungsten electrode
- Inert gas shielding for reduced contamination
- High precision and quality
- Suitable for thin and delicate components
- Lower deposition rate

## Plasma Arc Welding (PTAW)-based

- Uses a high-temperature plasma arc
- Excellent for refractory metals and alloys
- High energy density for robust material fusion
- Ideal for high-temperature applications
- Higher deposition rate

Laser - Based

## Laser + Wire

- Laser heats the wire, depositing material
- Wire acts as a consumable feedstock
- High precision and fine details
- Reduced heat-affected zone (HAZ)
- Low deposition rate

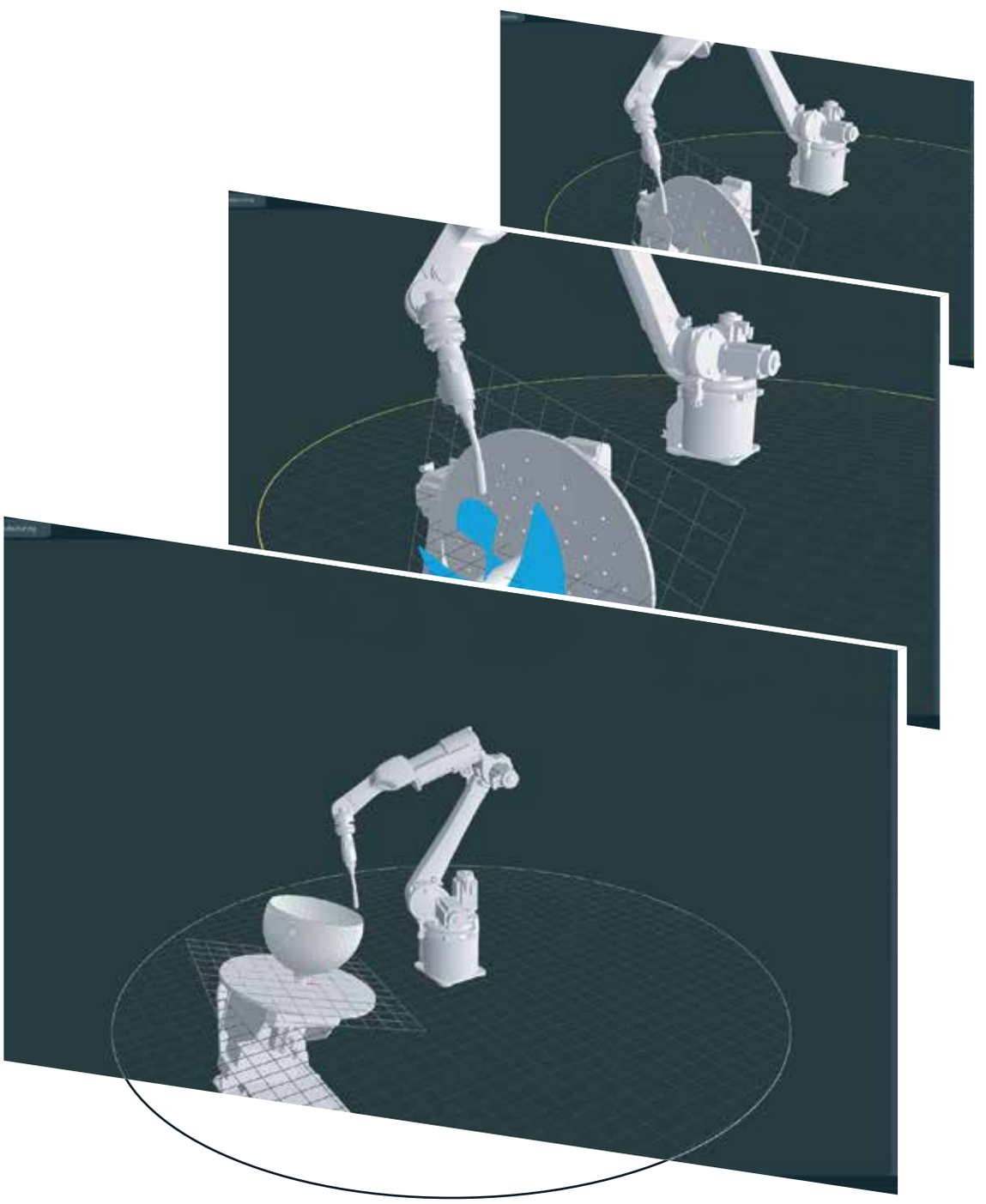
## Laser + Powder

- Laser melts and fuses powder material
- Precise deposition Geometries
- Broad material compatibility
- Complex geometries and high resolution
- Perfect solution for repairing

# MetalWorm Robotic Tool Path Planning Software

## With the MetalWorm Robotic Tool Path Planning Software, you can

- Perform tool path planning easily and quickly without expertise
- Verify production methodology with simulation
- Minimize pre-process preparation time
- Check pre-production, consumables requirements and lead time



## MetalWorm Robotic Tool Path Planning Software

**Tool Path Orientation Adjustment**

The tool path orientation can be built and improved based on the part geometry.

**Tool Path Planning by Region**

Part performance, weight, and printing capabilities can be enhanced by creating multiple tool path techniques in distinct regions

**Process Parameter Library**

Choose among a library of WAAM process parameters that can yield suitable mechanical and metallurgical qualities.

**Process Calibration**

Various process parameters, including wire feed speed, torch travel speed, current, and voltage, can be adjusted to deposit geometries with the given wall width and height while maximizing deposition efficiency.

**Robot & Process Simulation**

Execute simulations of part production using robot arms from ABB, Kuka, and Fanuc with resolved external axes kinematics.

**Flexible 3D Model Support**

Common network-based file formats such as STL, OBJ, 3MF, GLTF, STEP as well as Parasolid are supported.

**External Axis Support**

Unique interpolation techniques for gantry, slider, and positioner systems in different axes.

**Mesh Operations**

Isotropic and non-isotropic balance, boolean operations, and automatic repair.

**Customize Robot Programs**

Use ABB Rapid, Kuka KRL, Fanuc LS, or G Code create bespoke robot programs.

**Collision Detection**

Detect collisions between static and moving elements before printing.

**Multi-axis Tool Path Planning**

Different tool path techniques, including multi-planar slicing, non-planar, angular, b-spline, radial, conical, and rotational surfaces, can be created.

**Process Traceability**

Log, keep track of and document the entire printing process.

# Metalworm Diagnostic - Real-Time Process Monitoring Software

### Data Collection

Collects sensor and process data in real time and saves them in local database.

### Process and Sensors Data

Makes process-oriented calculations by using process and sensor data such as welding current, welding voltage, wire feed speed, torch travel speed, gas flow rate, temperature, humidity and oxygen.

### Real Time Graphs

Increases the traceability of the process with real time graphics.

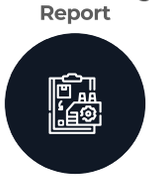
### Data Export

Exports data for further analysis.

### Audio and Visual Alerts

Gives audible and visual warnings depending on the deviations in the process parameters and user limits. All realized alerts are saved in the log.

### Manufactoring Report



Provides an interactive report for each of your production woks, including vision on production quality and large amounts of process data.

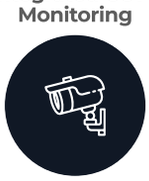
### Event Log

Keeps a comprehensive log of events, including alarms, errors and warnings that occur in the system.

### System Managment

Provides easy access to the status of cell, robotic system and safety equipment can be monitored.

### Integrated CCTV Monitoring



Records the process with various angles placed in the robotic system.

### Integrated ERP/MES


Integraes with existing ERP/MES systems, everything is recorded and made accessible to your organization for full traceability.

### System Errors and Warnings

Informs the operator of system warnings and errors. The relevant error codes of the welding robot system are displayed on the instrument panel to ensure fast continuation.

### 3D Graphs

Offers 3D graphics during and after part production and creates a 3D color map of the collected data.

# Metalworm Diagnostic - Real-Time Process Monitoring Software

We develop software solutions that make it easy to use
the full power of robotic additive manufacturing.

# 01 Compact Systems

Every event can be controlled during the working time by MetalWorm compact systems. Discover MetalWorm's robotic cell, designed specifically for additive manufacturing. The plug-and-play, user-friendly, and integrated components and technologies of the compact systems are all designed in a single cell.

## MHTTN1000

**Dimensions (W×D×H)**

2.4m×3.4m×2.4m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø0.7m×0.7m

**Number of Axes**

6+2

**Number of Stations**

1

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

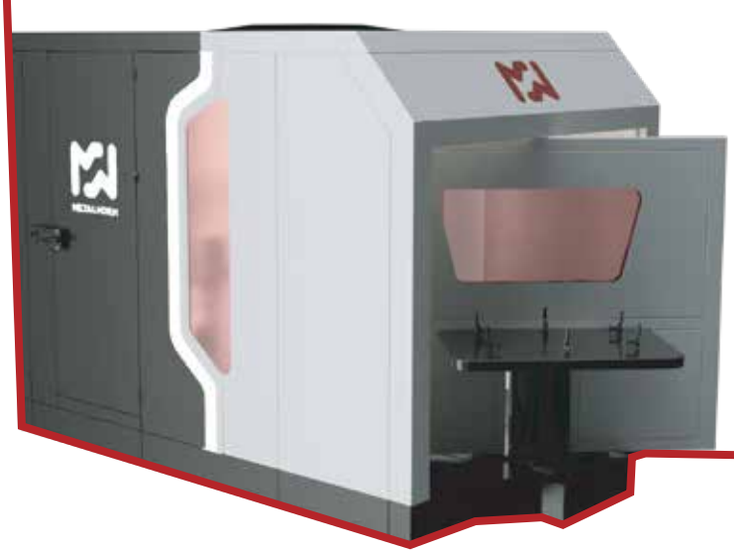
Two-Axis Compact Skyhook Positioner

**Positioner Payload**

1000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MHTTN500RP



**Dimensions (W×D×H)**

2.4m×3.4m×2.4m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø0.7m×0.7m

**Number of Axes**

6+2

**Number of Stations**

1

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

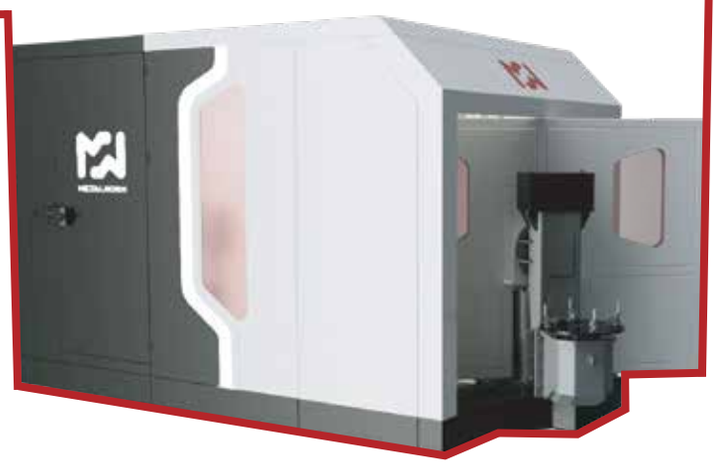
Two Station Rotary Positioner

**Positioner Payload**

500 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MHTTN500DS



*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

**Dimensions (W×D×H)**

2.4m×3.4m×2.4m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø0.7m×0.7m

**Power Source**

MIG/MAG/TIG

**Number of Axes**

6+5

**Number of Stations**

2

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

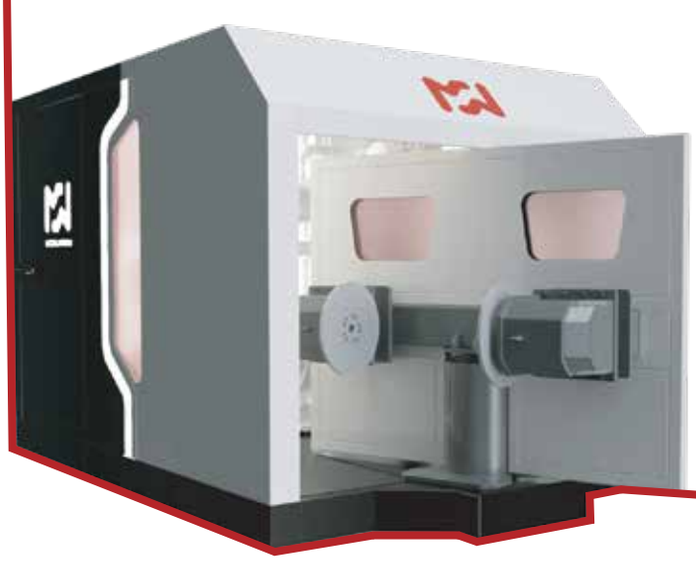
Double Skyhook

**Positioner Payload**

500 kg

It provides simultaneously production of the parts in 2 distinct stations.

## MHTTN500THDZ



**Dimensions (W×D×H)**

2.4m×3.4m×2.4m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø0.7m×0.7m

**Power Source**

MIG/MAG/TIG

**Number of Axes**

6+3

**Number of Stations**

2

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

THDZ Positioner

**Positioner Payload**

500 kg

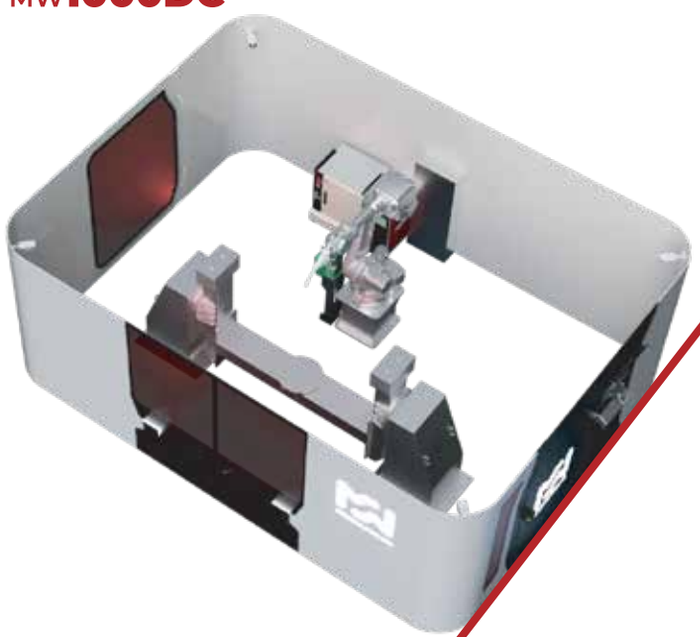
It provides simultaneously production of the parts in 2 distinct stations.

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

# 02 Expanded Systems

It provides robotic solutions for the manufacturing of larger parts for various industries and requirements.

## MW1000DC



**Dimensions (W×D×H)**

3.5m×3.5m×3m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø2m×1m

**Number of Axes**

6+2

**Number of Stations**

1

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

Drop Center Positioner

**Positioner Payload**

1000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MW2500ZGRP

**Dimensions (W×D×H)**

4m×4m×5m

**The Greatest Producible Component's Size (X-Y-Z)**

Ø2m×4m

**Number of Axes**

6+1+1

**Number of Stations**

1

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

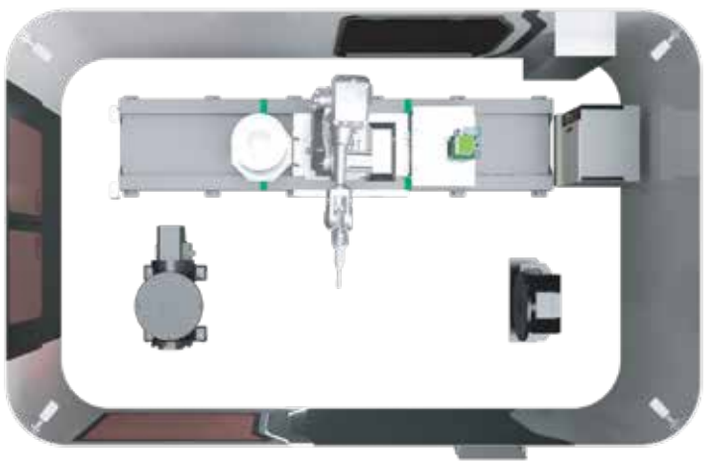
Z Axis and 1 Axis Rotary Positioner

**Positioner Payload**

2500 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MW1000S+CS



### Dimensions (W×D×H)

3.5m×3m×2.5m

### The Greatest Producible Component's Size (X-Y-Z)

Ø1m×1m

### Number of Axes

6+1+2

### Number of Stations

1

### Industrial Robot*

ABB-IRB2600ID-15/1.85

### System Components

Slider, 2 Axis Compact Skyhook, and Tail Side

### Positioner Payload

1000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MW5000S+T

### Dimensions (W×D×H)

3.5m×3m×2.5m

### The Greatest Producible Component's Size (X-Y-Z)

1m×2m×1m

### Number of Axes

6+1

### Number of Stations

1

### Industrial Robot*

ABB-IRB2600ID-15/1.85

### System Components

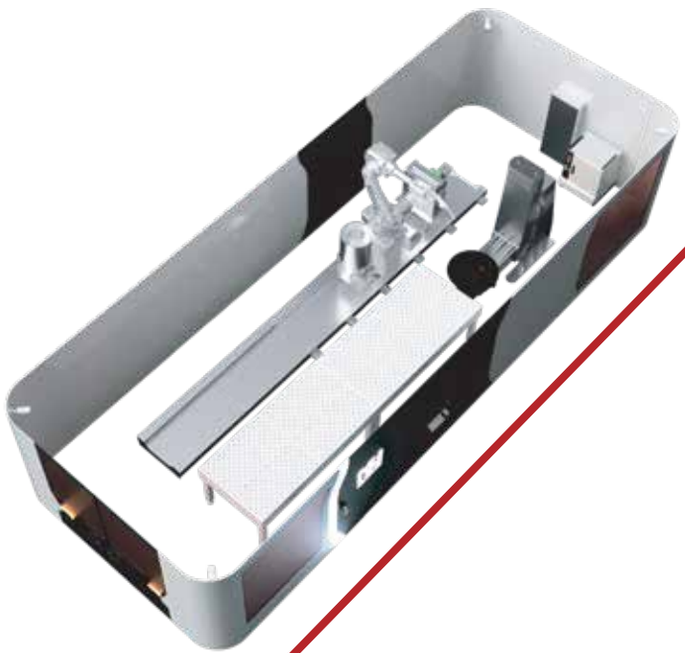
Slider and Table

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

# 02 Expanded Systems

It provides robotic solutions for the manufacturing of larger parts for various industries and requirements.

## MW5000S+SH



**Dimensions (W×D×H)**

7m×3m×2.5m

**The Greatest Producible Component's Size (X-Y-Z)**

On Positioner: Ø1m×1m  On Table: 1m×2m×1m

**Number of Axes**

6+1+2

**Number of Stations**

2

**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

Slider, 2 Axis Skyhook, and Table

**Positioner Payload**

1000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## MW5000DS+T

**Dimensions (W×D×H)**

3.5m×4.5m×2.5m

**The Greatest Producible Component's Size (X-Y-Z)**

1m×2m×1m

**Number of Axes**

2×(6 + 1)

**Number of Stations**

1

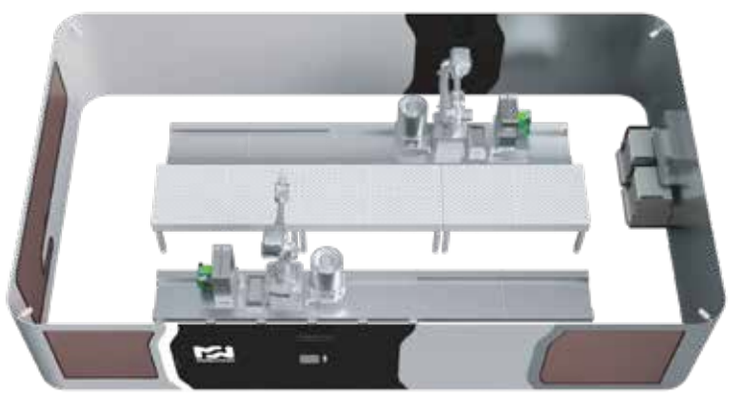
**Industrial Robot***

ABB-IRB2600ID-15/1.85

**System Components**

Slider, Table

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.



## MW5000DS+SH

### Dimensions (W×D×H)

7m×4.5m×2.5m

### The Greatest Producible Component's Size (X-Y-Z)

On Positioner: Ø1m×1m  On Table: 1m×2m×1m

### Number of Axes

2×(6 + 1) + 2

### Number of Stations

2

### Industrial Robot*

ABB-IRB2600ID-15/1.85

### System Components

Slider, 2 Axis Skyhook, and Table

### Positioner Payload

1000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.

## Hybrid Gantry Robotic WAAM System

### Dimensions (W×D×H)

6m x 6m x 5.8m

### The Greatest Producible Component's Size (X-Y-Z)

Ø 2.6m x 2.8m

### Number of Axes

6 + 5

### Number of Stations

1

### Industrial Robot*

ABB-IRB2600ID-15/1.85

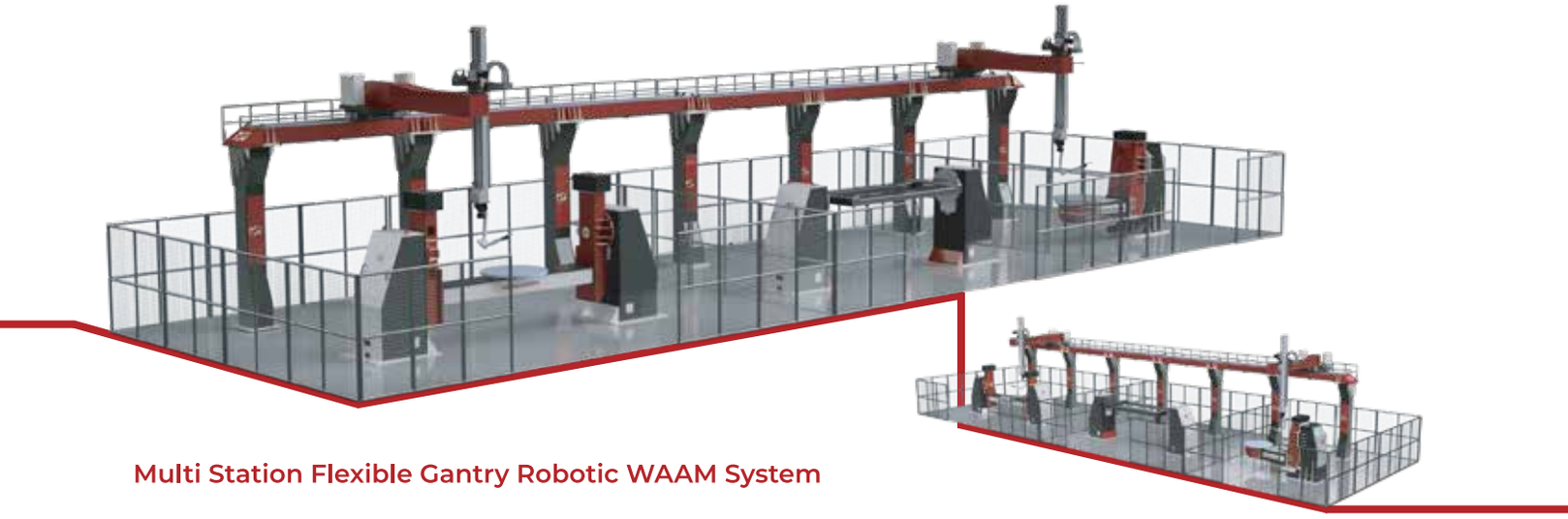
### System Components

Hybrid Gantry

### Positioner Payload

5000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.



## Multi Station Flexible Gantry Robotic WAAM System

### Dimensions (W×D×H)

35 x 10.8 x 9m

### Manufacturing Volume (X,Y,Z)

Station-1: Drop Center - Up to Ø2.6 x 3.5m
Station-2: TH Positioner - Up to 2.5 x 5m
Station-3: Skyhook - Up to Ø3 x 3.5m

### Number of Axes

2x(6+3) + 2 + 1 + 2

### Number of Stations

3

### Industrial Robot*

ABB-IRB2600ID-15/1.85

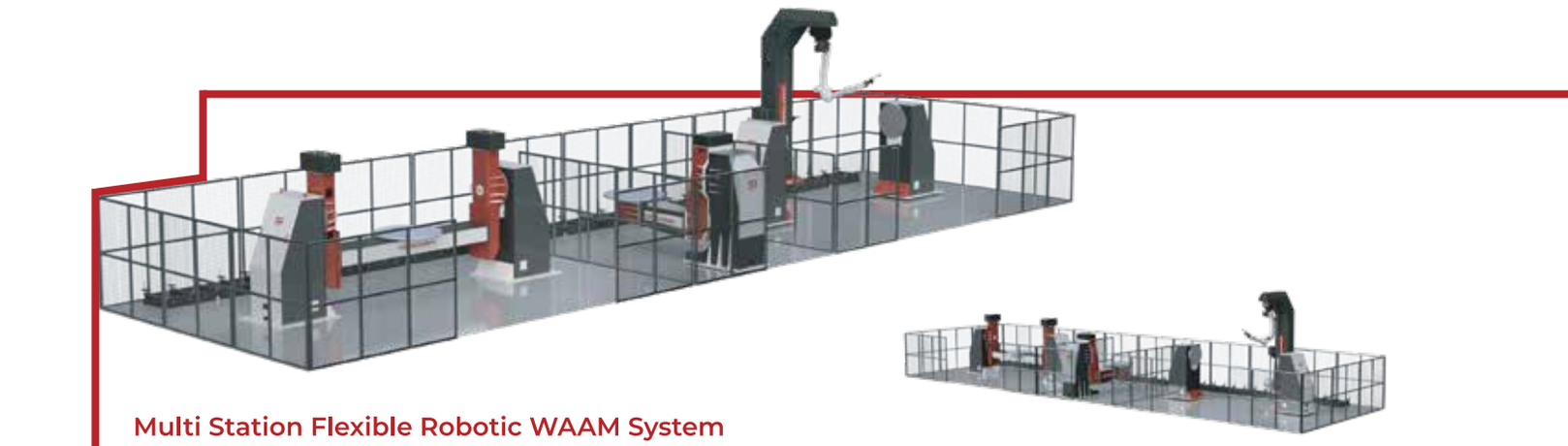
### System Components

Gantry, Drop Center, TH Positioner, Skyhook

### Positioner Payload

Station-1: Drop Center - Up to 10.000 kg
Station-2: TH Positioner - Up to 20.000 kg
Station-3: Skyhook - Up to 5.000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.



## Multi Station Flexible Robotic WAAM System

### Dimensions (W×D×H)

28.5 x 8 x 8.4m

### Manufacturing Volume (X,Y,Z)

Station-1: Drop Center - Up to Ø2.6 x 2m
Station-2: TH Positioner - Up to 2.5 x 5m
Station-3: Skyhook - Up to Ø3 x2m

### Number of Axes

2x(6+3) + 2 + 1 + 2

### Number of Stations

3

### Industrial Robot*

ABB-IRB2600ID-15/1.85

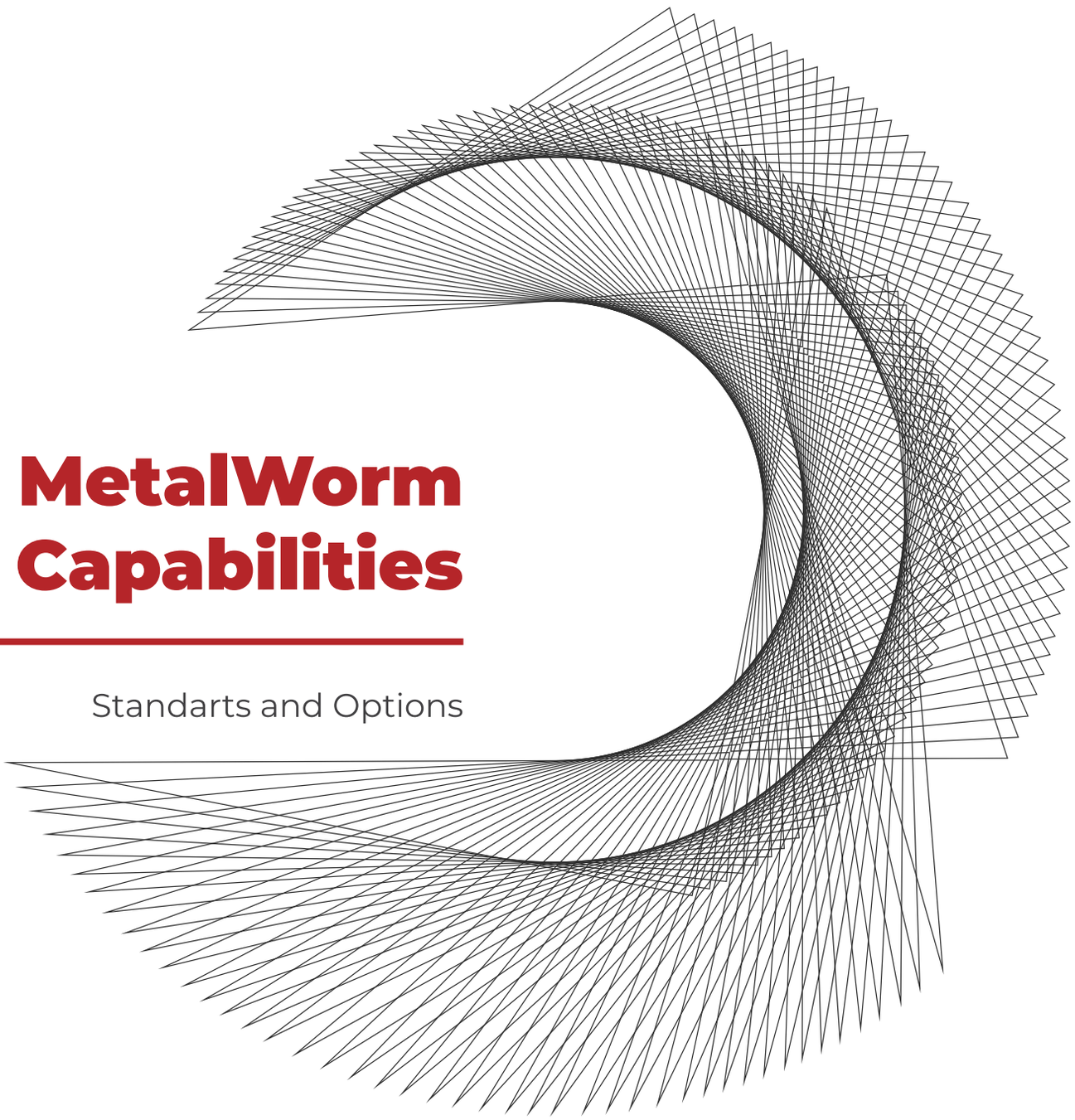
### System Components

Slider, C Column, Drop Center, TH Positioner, Skyhook

### Positioner Payload

Station-1: Drop Center - Up to 10.000 kg
Station-2: TH Positioner - Up to 20.000 kg
Station-3: Skyhook - Up to 5.000 kg

*The robot brand and system model may change depending on the industry and area of use. Our systems can be integrated by KUKA, FANUC, and ABB robots.



# MetalWorm Capabilities

Standarts and Options

# 03 Custom Systems

Give us a call and we'll design a unique solution for you if none of these solutions still don't fit your needs.

## MetalWorm Capability - Product Options

The unique process solutions of
Metalworm applied to all other systems

| Sensor | Standard | Advanced |
|---|---|---|
| Pyrometer | Available | Available |
| Laser Distance Sensor | Unavailable | Available |
| In-Cell Humidity Sensor | Unavailable | Available |
| In-Cell Temperature Sensor | Unavailable | Optional |
| In-Cell Oxygen Sensor | Unavailable | Available |
| Gas Flow Meter | Unavailable | Available |
| Thermal Welding Camera | Unavailable | Available |
| Welding Camera (HDR) | Unavailable | Optional |
| Thermal Camera (IR) | Unavailable | Optional |
| Microphone | Unavailable | Optional |
| 3D Camera | Unavailable | Optional |
| Laser Profiler | Unavailable | Optional |
| Welding Current and Voltage Sensor | Unavailable | Optional |

| | Standard | Advanced |
|---|---|---|
| Power Source | MIG/MAG/TIG/ Plasma/Laser* | MIG/MAG/TIG/ Plasma/Laser* |
| Torch Cleaning | Available | Available |
| In-Cell Lighting System | Available | Available |
| Industrial Safety Equipment | Available | Available |
| CCTV | Available | Available |

| MetalWorm Add-On | Standard | Advanced |
|---|---|---|
| Active Cooling Technology | Optional | Optional |
| In-situ Heating Technology | Optional | Optional |
| Vibration Technology | Optional | Optional |

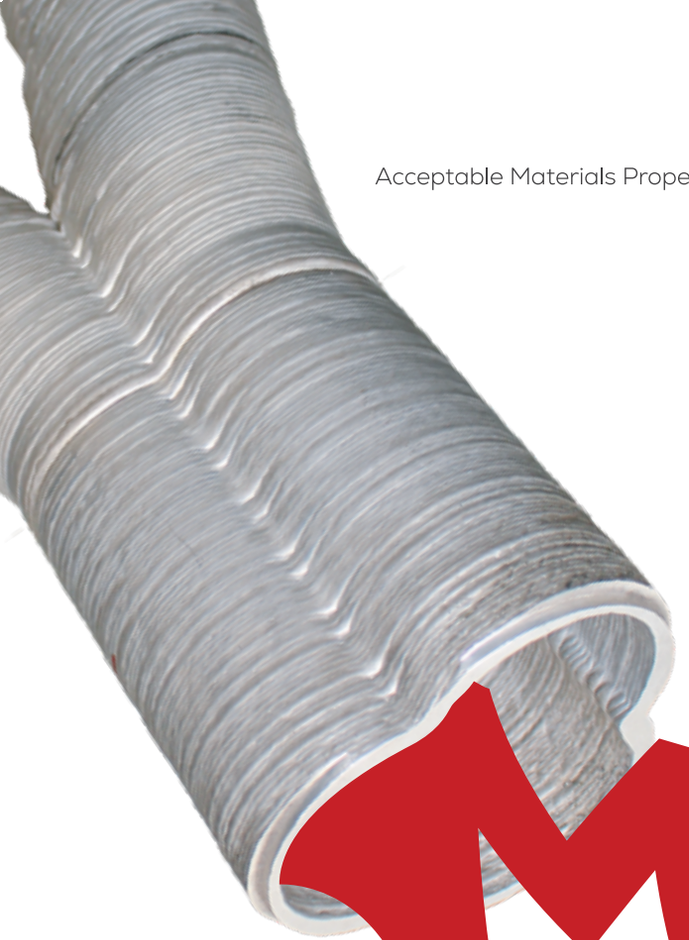
| MetalWorm Options | Standard | Advanced |
|---|---|---|
| Gas Filter | Optional | Optional |
| Fixture/Clamp | Optional | Optional |
| Transfer the Manufactured Part out of the Cell - Crane | Optional | Optional |
| Transfer the Manufactured Part out of the Cell - Trolley | Optional | Optional |

| MetalWorm Software | Standard | Advanced |
|---|---|---|
| Offline Programme | Available | Available |
| Diagnostic | Available | Available |
| Machine Vision | Unvailable | Available |
| Control | Unvailable | Available |
| Anomaly Detection | Unvailable | Available |

Acceptable Materials Properties

Process Specific Library

Optimized Parameters for Various Materials



# Materials

## “Choose materials that have the structural potential to sustain and bear the building loads”

MetalWorm can be used to build parts utilizing a variety of metals and alloys. A number of materials have been used, and the relevant mechanical properties have been shared in the process library. MetalWorm team continues its research on new materials and will soon release the process specifications for all capable materials.

Our approach and integrated technologies at MetalWorm are particularly adaptable to practically any material, which results in excellent mechanical qualities of WAAM manufactured components.

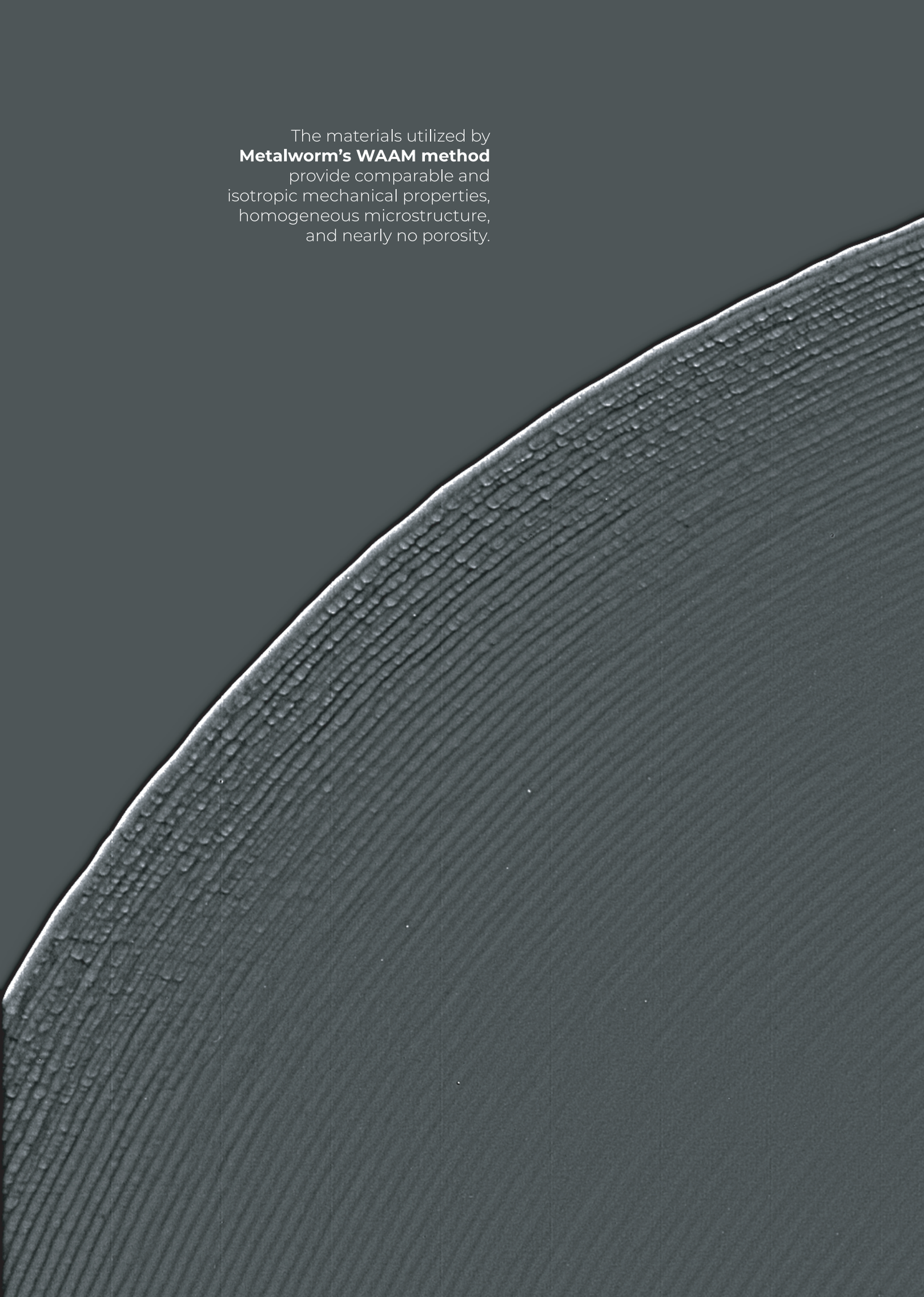
## A good material is one that has:

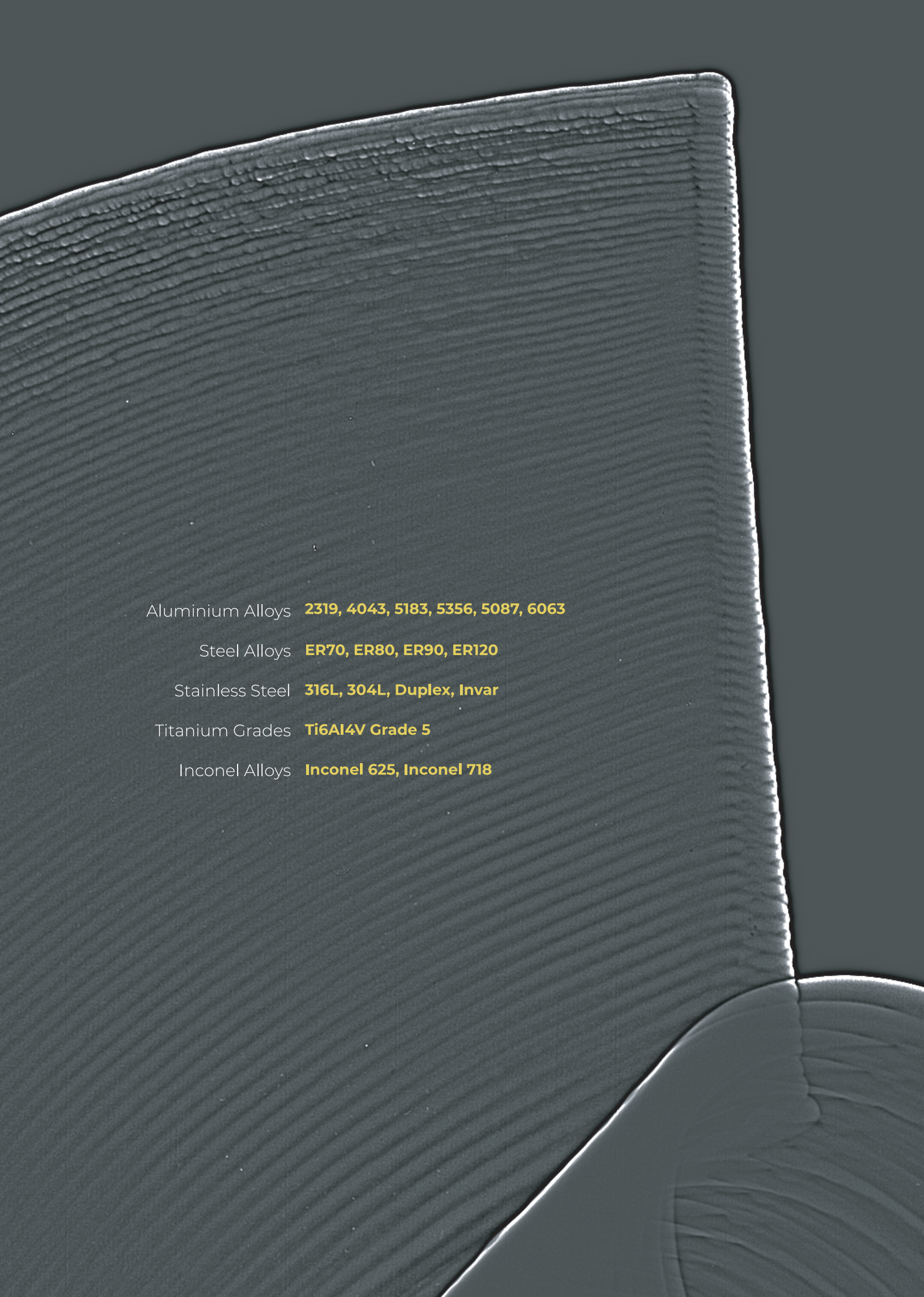
No microstructural defects such as porosity

Isotropic mechanical characteristics

Homogeneous microstructure

The materials utilized by **Metalworm's WAAM method** provide comparable and isotropic mechanical properties, homogeneous microstructure, and nearly no porosity.





| | |
|---|---|
| Aluminium Alloys | **2319, 4043, 5183, 5356, 5087, 6063** |
| Steel Alloys | **ER70, ER80, ER90, ER120** |
| Stainless Steel | **316L, 304L, Duplex, Invar** |
| Titanium Grades | **Ti6Al4V Grade 5** |
| Inconel Alloys | **Inconel 625, Inconel 718** |

**Revolutionizing Industry,**
**Reshaping Sustainability**

# ER70S-6 G42 4 M21 3Si1

Wire

**Key Features**

| | | | |
|---|---|---|---|
| Excellent ductility | Low cost | High toughness | Machinability |

**Applications**

| | | | | | |
|---|---|---|---|---|---|
| General fabrications | Automotive | Pipes | Structural steel | Carbon steel plate | Sheet metal applications |

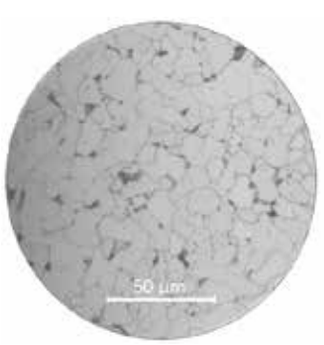
## Chemical Composition

| Component | C | Si | Mn | P | S | Cr | Mo | Ni | Cu | V | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight Percent (we%) | 0.13 | 0.7 | 1.16 | 0.0103 | 0.025 | 0.025 | 0.01 | 0.03 | 0.1 | 0.002 | Bal |

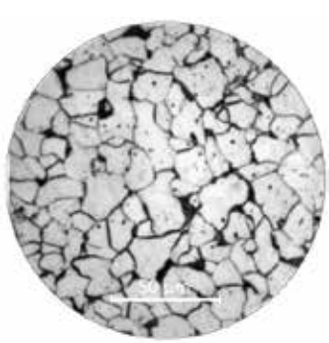
## Mechanical Properties

| Material | Tensile Strength (MPa) | Yield Strength (MPa) | Elongation (%) | Hardness (HV) | Hardness (HB) |
|---|---|---|---|---|---|
| MetalWorm WAAM 70S-6 | 485 @ LD [2]<br>480 @ ND[3] | 357 @ LD<br>356 @ ND | 32 @ LD<br>30 @ ND | 170 | 160 |
| ASTM A285 Grade C [4] | 360-515 | 205 | 23-27 | N/A | N/A |


## Microstructure




WAAM ER70S-6 @ MetalWorm



Reference ST-37 steel alloy

The microstructure of WAAM fabricated ER70S-6 is typical microstructure of low carbon steel. The dominant microstructure is equiaxed primary ferrite grains which are bonded within the secondary phase of lamellar pearlite phases.

[ 1 ] Tensiletestswerecarriedoutatroomtemperature,accordingtoASTME8standardwiththicknessof6mmandloadingspeedof0.25mm/s.
[2] LD corresponds to longitudinal or deposition direction.
[3] ND corresponds to normal or building direction.
[4] The data are taken from Masteel UK Limited, https://masteel.co.uk/astm-a285/

# ER5356 DIN 3.3536, EN ISO 18273 S Al 5356 (AlMg5Cr(A))

Wire

**Key Features**

| | | | |
|---|---|---|---|
| Medium strength | High ductility | Excellent corrosion resistance | Good feedability |

**Applications**

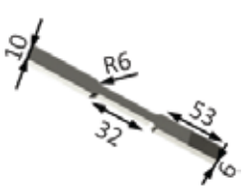
| | | | |
|---|---|---|---|
| Structural materials in marine | Automotive | Aircraft | Cryogenic application |

## Chemical Composition

| Component | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti | Al |
|---|---|---|---|---|---|---|---|---|---|
| Weight Percent (we%) | 0.05 | 0.1 | 0.001 | 0.1 | 4.75 | 0.1 | 0.003 | 0.1 | Bal |

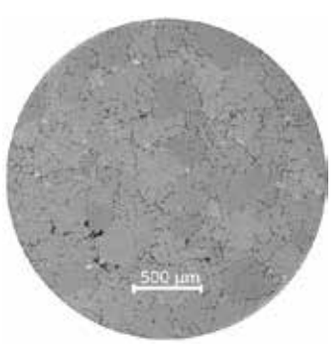
## Mechanical Properties

| Material | Tensile Strenght (MPa) | Yield Strenght (MPa) | Elongation (%) | Hardness (HV) | Hardness (HB) |
|---|---|---|---|---|---|
| MetalWorm WAAM ER5356 | 300 @ LD [2]<br>295 @ ND[3] | 195 @ LD<br>200 @ ND | 30 @ LD<br>18 @ ND | 86 | 82 |
| As-fabricated 5019 aluminum [4] | 280 | 130 | 16 | N/A | N/A |




## Microstructure


WAAM ER5356 @ MetalWorm




Reference 5019 Aluminum alloy [5]

The microstructure of WAAM fabricated ER5356 is similar to the microstructure of 5019 aluminum alloy. The microstructure consists of columnar, planar, dendritic, and equiaxed grains. Different grain morphologoies are effected by various cooling rates in different region of WAAM fabricated ER5356 aluminum alloy.

[ 1 ] Tensile tests were carried out at room temperature, according to ASTM E8 standard with thickness of 6mm and loading speed of 0.25mm/s.
[2] LD corresponds to longitudinal or deposition direction.
[3] ND corresponds to normal or building direction.
[4] The data correspond to 5019 aluminum and are taken from: https://www.makeitfrom.com/material-properties/5019-F-Aluminum
[5] The image is taken from: doi:10.4028/www.scientific.net/KEM.682.10

# ER4043

DIN 3.2245, EN ISO 18273 S Al 4043 (AlSi5)

Wire

**Key Features**

| | | | |
|---|---|---|---|
| Excellent machinabiliy | Excellent formability | Good strength | Good corrosion resistance properties |

**Applications**

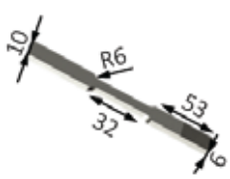
| | | |
|---|---|---|
| Bicycle Trucks | Automotive | Trailers |

Chemical Composition

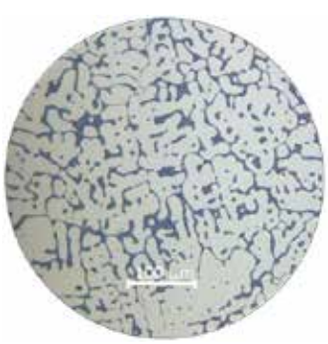
| Component | Si | Fe | Cu | Mn | Mg | Cr | Zn | Al |
|---|---|---|---|---|---|---|---|---|
| Weight Percent (we%) | 5 | 0.1 | 0.001 | 0.05 | 0.03 | 0.001 | 0.003 | Bal |

Mechanical Properties

| Material | Tensile Strenght (MPa) | Yield Strenght (MPa) | Elongation (%) | Hardness (HV) | Hardness (HRC) |
|---|---|---|---|---|---|
| MetalWorm WAAM 4043 | 158 @ LD [2]<br>157 @ ND[3] | 99 @ LD<br>93 @ ND | 19 @ LD<br>23 @ ND | 45 | 39 |
| As cast Al-Si alloy [4] | 127 | 120 | 10.7 | N/A | N/A |




Microstructure



WAAM ER4043 @ MetalWorm

As cast Al-Si alloy [5]

The microstructure of WAAM fabricated ER4043 is typical microstructure of Al-Si alloy. The dominant microstructure consists of primary aluminium dendrite (α-Al) structure embedded in Al-Si eutectic.

[1] Tensile tests were carried out at room temperature, according to ASTM E8 standard with thickness of 6 mm and loading speed of 0.25 mm/s.
[2] LD corresponds to longitudinal or deposition direction.
[3] ND corresponds to normal or building direction.
[4] The data are taken from: doi:10.3390/ma10070786
[5] The image is taken from: doi:10.3390/ma10070786

# ER316LSI Stainless Steel
G19123LSi

Wire

**Key Features**

| | | | |
|---|---|---|---|
| High resistance | Heat resistance | Superior corrosion resistance | Fabrication ease |

**Applications**

| | | | | |
|---|---|---|---|---|
| Marine | Medical Implants | Food Industry | Heat echanger | Architectural application |

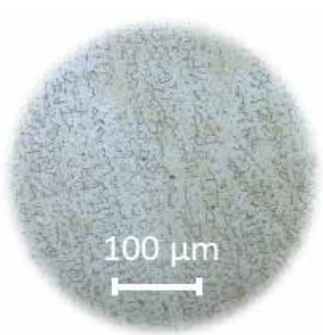
Chemical Composition

| Component | Si | Fe | Mn | P | S | Ni | N | Mo | Fe |
|---|---|---|---|---|---|---|---|---|---|
| Weight Percent (wt.%) | 0.02 | 0.7 | 1.9 | 0.045 | 0.015 | 11.5 | 0.09 | 2.5 | 2.5 |

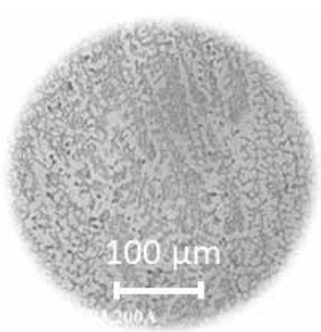
Mechanical Properties

| Material | Tensile Strenght (MPa) | Yield Strenght (MPa) | Elongation (%) | Hardness (HV) | Hardness (HB) |
|---|---|---|---|---|---|
| MetalWorm WAAM 316LSI | 599 @ LD [2]<br>614 @ ND[3] | 363 @ LD<br>398 @ ND | 32 @ LD<br>33 @ ND | 184 | 174 |
| AISI 316L Stainless Steel | 485 | 220 | 45 | N/A | N/A |


Microstructure



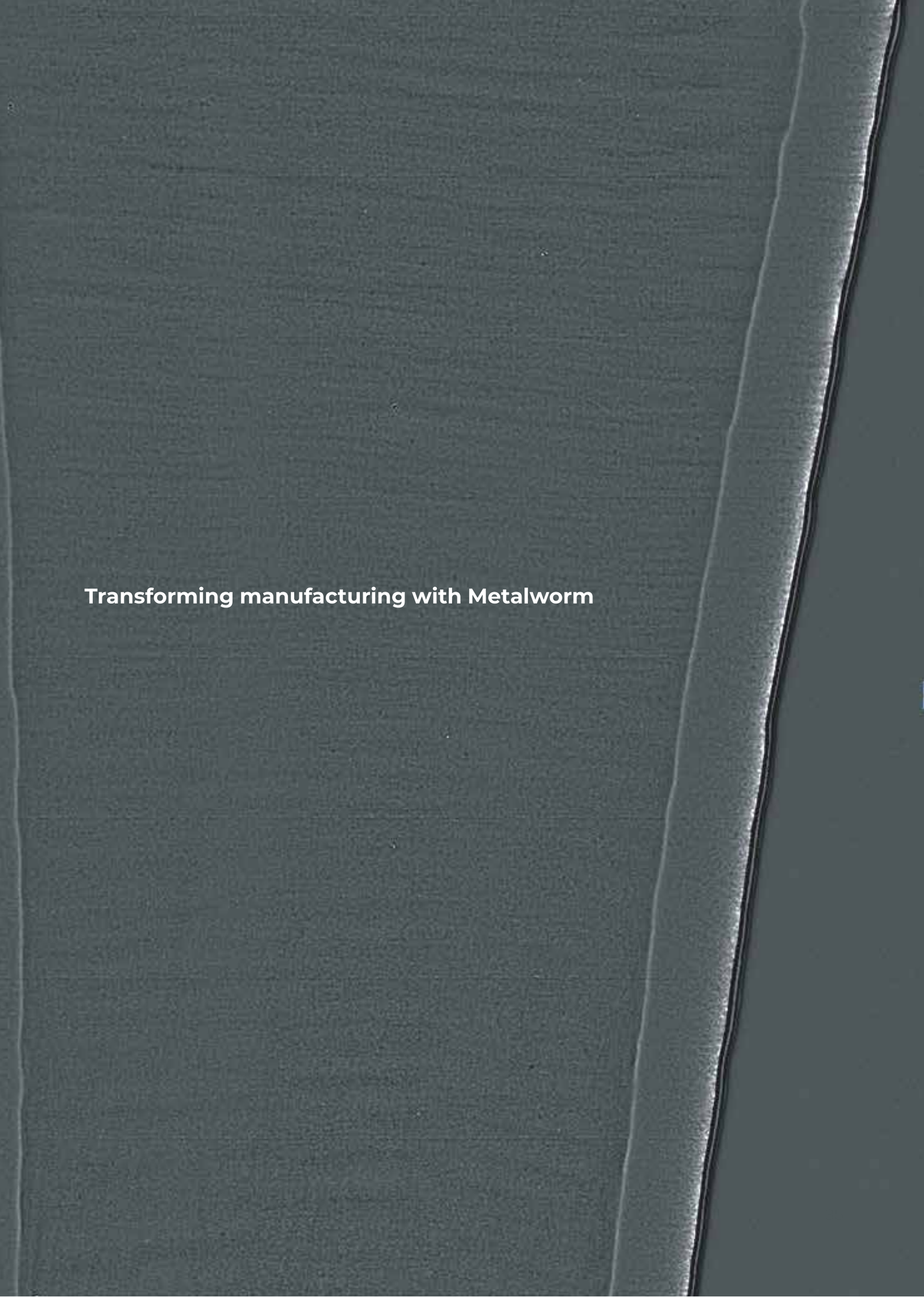

WAAM 316L Stainless Steel @ MetalWorm




Reference AISI316L Stainless Steel [5]

The microstructure of WAAM fabricated 316L stainless steel consists of austenitic matrix and delta ferrite in the interdendritic spacesis.

[ 1 ] Tensile tests were carried out at room temperature, according to ASTM E8 standard with thickness of 6 mm and loading speed of 0.25 mm/s.
[2] LD corresponds to longitudinal or deposition direction.
[3] ND corresponds to normal or building direction.
[4] The data are taken from: https://doi.org/10.1016/j.jmrt.2022.08.074
[5] The image is taken from: https://doi.org/10.1016/j.jmrt.2019.11.004


Transforming manufacturing with Metalworm

## Samples

## Airfoil ER5356 Aluminum Alloy

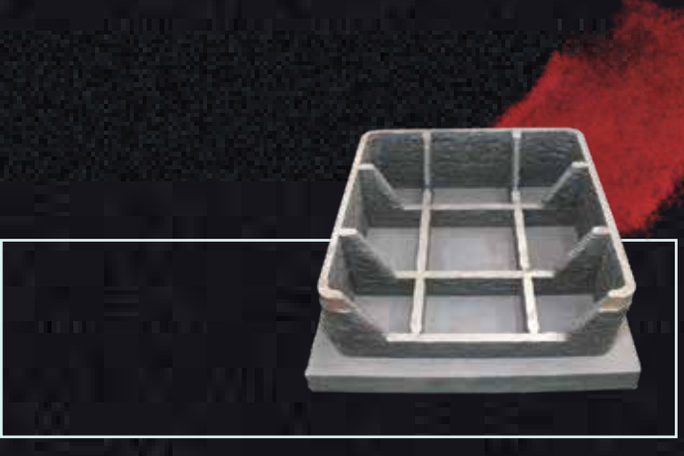
| Size | Weight | Print Time |
|---|---|---|
| 250x100x200mm | 1.46kg | 1h 46m |

## Oil and Gas ER70S-6 Steel Alloy

| Size | Weight | Print Time |
|---|---|---|
| Ø 435 x 300mm | 51.39kg | 48h 20m |

## Propeller

| Size | Weight | Print Time |
|---|---|---|
| Ø380x80mm | 3.8kg | 11h 57m |



## Landing Gear Part ER70S-6 Steel Alloy

| Size | Weight | Print Time |
|---|---|---|
| 300x300x100mm | 11.8kg | 12h 43m |

## COCOON ER70S-6 Steel Alloy

| Size | Weight | Print Time |
|---|---|---|
| Ø300x1000mm | 45kg | 38h 0m |

## Dome Shape Mold Part Invar 36

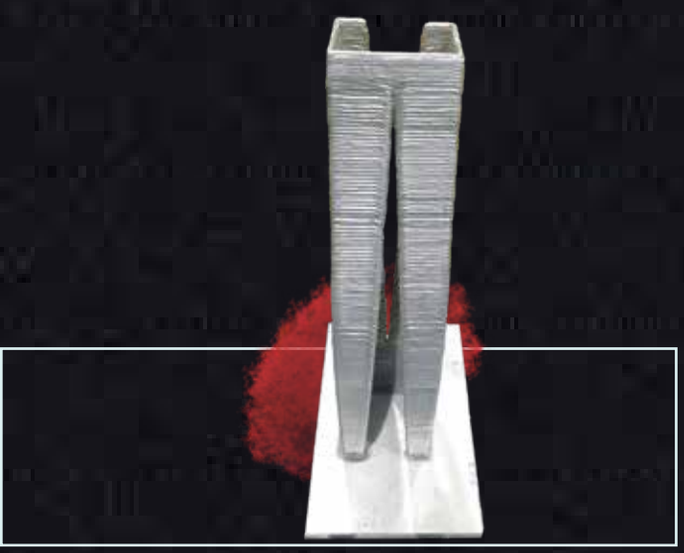
| Size | Weight | Print Time |
|---|---|---|
| Ø400x100mm | 35.5kg | 18h 24m |

## Organic Structure ER4043 Aluminum Alloy

| Size | Weight | Print Time |
|---|---|---|
| 150x150x360mm | 2.66kg | 3h 15m |

## Rocket Nozzle ER316LSi Stainless Steel

| Size | Weight | Print Time |
|---|---|---|
| Ø250x400mm | 14kg | 10h 59m |



## Art Part ER5356 Aluminum Alloy

| Size | Weight | Print Time |
|---|---|---|
| 160x100x505mm | 3.9kg | 5h 30m |

## Bent Pipe Model ER5356 Aluminum Alloy

| Size | Weight | Print Time |
|---|---|---|
| Ø85x220mm | 1.64kg | 1h 59m |

## Hexagon Lofted to Circle Profil ER5356 Alimunim Alloy

| Size | Weight | Print Time |
|---|---|---|
| 140x120x190mm | 1.88kg | 2h 16m |

## Helix ER70S-6 Steel Alloy

| Size | Weight | Print Time |
|---|---|---|
| Ø95x275mm | 1kg | 2h 27m |

# Industries

## Manufacturing

Produce components that are fit for your needs in the manufacturing industry with extremely low buy-to-fly rates using Metalworm's brand-new, and cutting-edge technology.

## Aviation

With Metalworm, it is simple to create components for the aviation industry that are enormous in size but have very little tolerance, in the desired shape and thickness, with high ravings on raw material cost.

## Space

Time and material requirements for producing complicated shapes have significantly decreased thanks to 3D metal printing. Your expert solution partner in this case will be Metalworm.

## Automotive

Utilize Metalworm's benefit to create a controlled process, focusing on low cost and high repeatability

## Maritime

Possess the benefit of manufacturing quickly rather than having to wait for the fabrication of large parts needed by the marine sector. Repair small wear and mistakes insteal of scrapping expensive parts.



## Defense

With MetalWorm, you can accomplish your sustainability goals, manage your supply chain more effectively, create low-cost high-complexity parts, and shorten the lead time for your project.

## Energy

Time and material requirements for producing complicated shapes have significantly decreased thanks to 3D metal printing. Your expert solution partner in this case will be Metalworm.

## Oil & Gas

Oil and gas industries are able to significantly save production costs, improve operational procedures, and develop new, more effective methods for designing, producing, and maintaining equipment by using WAAM.

## Research Center

Development of new materials that can be utilized in the WAAM process, understand the process and detect any problems that may arise during and after WAAM, Control the process parameters to achieve desired mechanical properties, and scientifically support your industrial targets using technologies that have been integrated in MetalWorm.



JUST LIKE SILKWORMS

Teknopark Ankara, 2224. Cad. No:1 B Blok Zemin Kat, 06378,
İvedik Osb/Yenimahalle/Ankara/TÜRKİYE