

AML's PM-Wire Magnets: Thinking Outside the Block

Dr. Philippe Masson. CTO

Rare Earth Mines, Magnets & Motors 2026

Toronto, Canada

September 30, 2026

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Our Vision & Mission

Building a better magnet for customers

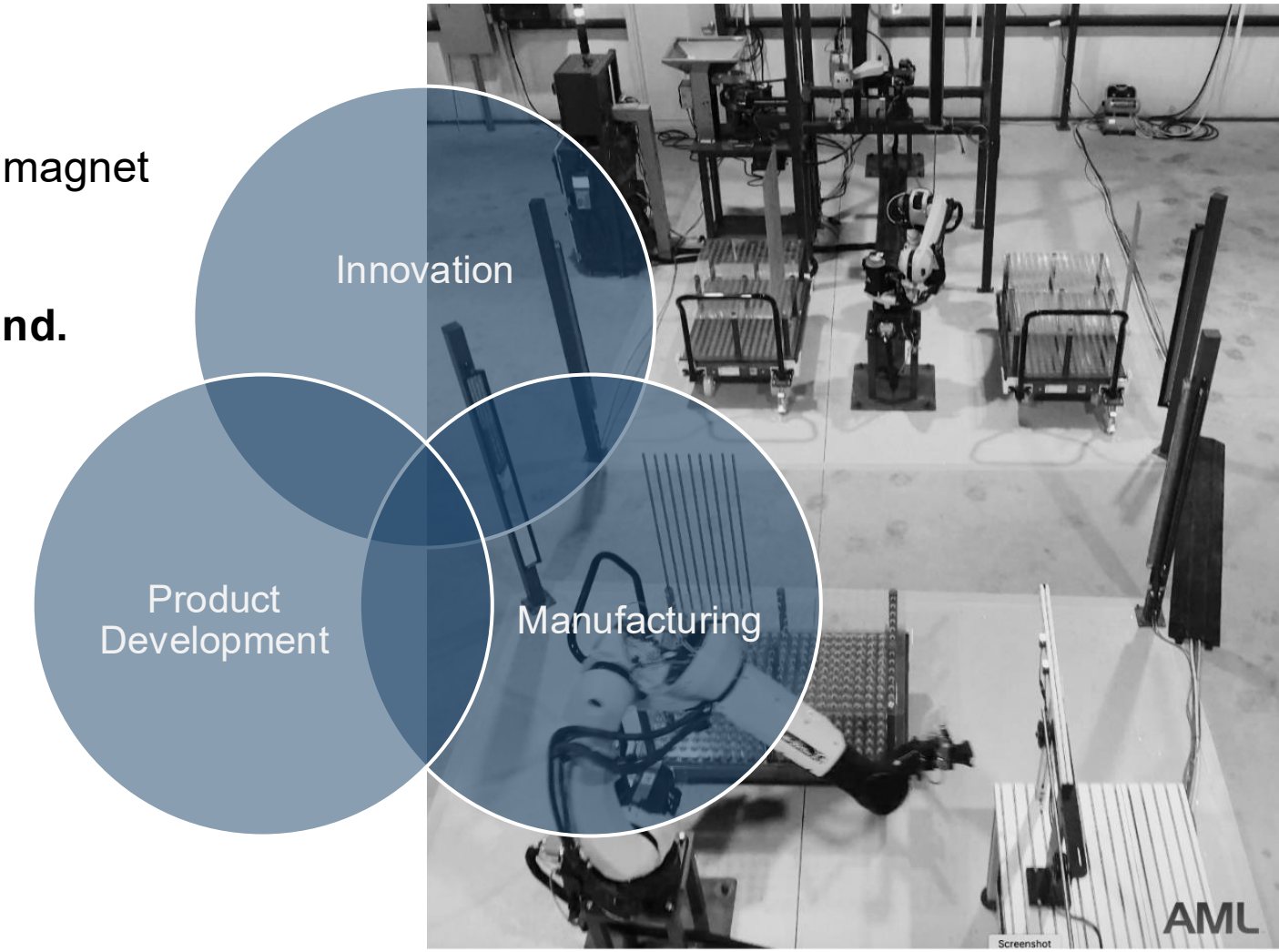
We believe that product innovation should drive magnet design.

Permanent magnets begin with the end in mind.

Establish the goal
What are you looking to achieve?

Determine the path to get there
Cost, supply chains, and manufacturability.

Execute on manufacturing
Magnet solutions enabling manufacturing benefits for customers.



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The AML Story

Founded in 1995 as a startup built on the backdrop of the reindustrialization of America

Rich history in magnetics, robotics, and manufacturing.

Deep IP portfolio and knowhow.

World-class manufacturing capabilities and execution.

Converging on technology with market opportunities that change the world

	1995	2007	2015	2020	2026+
Business	Particle beam accelerator research	Superconducting technologies	Permanent magnet technologies	PM product development	Pilot PM manufacturing scale up
Products	Research and development	Superconducting magnets and systems	PM-Wire™ patent filings & IP development	PM-Wire™ proof of concept	PM-Wire™ permanent magnets
Markets	Government grants and research	Energy, medical, and scientific research	General industry and applications	Motors and generators	Motors, generators, transportation, and more..

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AML Today

AML is a leader in the development of magnet-based application and advanced manufacturing solutions for permanent magnets.

Leadership



Wade Senti President & CEO

- Leads all of AML's major transactions; supported $10M+ in strategic capital to date
- Responsible for corporate, financial, customer relationships, and strategic affairs
- 15+ years of experience in finance, transactions, and business strategy
- Bachelor of Science in Accounting (BSAc), University of Florida



Philippe Masson Chief Technology Officer

- Co-inventor of several of AML's game-changing permanent magnet technologies
- Leads AML technology development and customer programs
- 20+ years developing superconducting applications and permanent magnet technologies
- Ph.D. in Electrical Engineering, Université Henri Poincaré, Nancy, France

Quick Facts

Leading minds in magnetics and advanced manufacturing

Founder mindset driven by vested stake in business

10+ years working together with technology and supply chain development

Experienced engineering, science, and manufacturing team

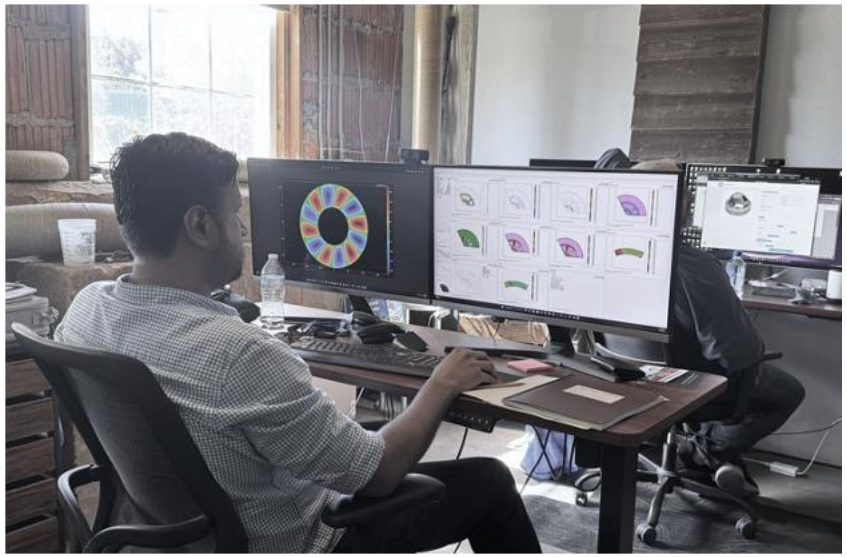
Proven Technology | Advanced Manufacturing | Scaling with Customers | $19.1M Total Funding

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Our Capabilities

Building domestic capacity to meet customers needs





Advanced Magnetics and Manufacturing



Our Company	Facilities	Material Science	Application Design	Manufacturing
	R&D and manufacturing	Development and processing	Proprietary software tools	Prototyping and scaled

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Strategic Engagements

Industry and government support for PM-Wire™ development

Partner	Period	Amount	Program
Aerospace & Defense Firm Industry partner	2020 – 2021	**$1.00M**	Proof of concept of PM-Wire™ with anisotropic NdFeB materials for non-sintered magnets
Defense Innovation Unit U.S. Department of War	2020 – 2022	**$1.70M**	PM-Wire™ pilot manufacturing line framework and automation capabilities
DOE ARPA-E (ASCEND) U.S. Department of Energy	2021 – 2025	**$1.63M**	Permanent magnet technology design and proof of concept for novel configuration
Defense Logistics Agency U.S. Department of War	2022 – 2025	**$2.39M**	Sintered magnet manufacturing development and PM-Wire™ development
Defense Logistics Agency U.S. Department of War	2026 – present	**$2.00M**	Qualification of PM-Wire™ sintered magnets for defense customers

DEFENSE INNOVATION UNIT

U.S. Department of War

U.S. DEPARTMENT of ENERGY

NAVAL NUCLEAR LABORATORY

CMI Critical Materials Innovation Hub

Track Record

- **6+** Years of continuous program support
- **5** Funded development & qualification programs
- **3** U.S. federal sponsors: DIU, DLA, DOE
- **5+** Magnet material pathways

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Our Intellectual Property

Active patents and published applications

	Description	Jurisdiction	Patent #	Application #	Grant Date
Manufacturing	**Method of Manufacturing Permanent Magnets**	United States	**11,842,832**	16/089,716	1/31/24
		Europe	**3440678**	17776725.8	4/30/25
		United States	**Application**	18/369,683	N/A
		Europe	**Application**	242056653	N/A
		Europe	**Application**	23 205 665.3	N/A
	Method for Continuous Manufacturing of Permanent Magnets	United States	**12,542,236**	17/981,398	2/3/26
		Europe	**Application**	21 800 922.3	N/A
Magnet Configurations	**Dual Rotor Electrical Machines**	United States	**10,892,672**	16/089,622	1/12/21
		United States	**11,575,301**	17/146,381	2/7/23
		United States	**12,003,152**	18/106,429	6/4/24
		United States	**12,506,390**	18/732,089	12/23/25
	Electric Machines Using Axially-Magnetized Curvilinear PMs	United States	**12,081,076**	18/222,382	9/3/24
		United States	**Application**	18/822,425	N/A
		Europe	**Application**	22740191.6	N/A
		Australia	**Application**	2022208708	N/A
		Brazil	**Application**	1120230140	N/A

At a Glance

8
Granted Patents

8
Pending Applications

Extensive Trade Secrets
Proprietary processes in software, magnetization, and manufacturing

*Does not include trade secrets or non-public patent applications or pending application filings.

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A New Frontier for Permanent Magnets

PM-Wire™ creating wider opportunities for magnet materials

Simplified process

✓ Fewer steps, adaptable, and product driven, unlike traditional form or block pressing.

Proprietary magnetization

✓ Smart magnet design begins with novel abilities to make the best use of magnet materials.

Rapid industrialization

✓ Modular and scalable for integration into a high-rate manufacturing environment.

Material flexibility

✓ Works with a wide range of magnet materials for greater supply chain autonomy.

	PM-Wire™ Process	China
Process	Powder in tube	Die, mold + press
Design Approach	Product design leads magnet design	Magnet configuration limits product design
Performance	Magnet shape and magnetization drive application performance	Performance is only driven by higher grade materials
Value	Magnet design adds application value	Magnet is a commodity
Supply Chain	Supply chain autonomy	Controls rare earth material supply

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Enabling Magnet Materials

Addressing a wide array of material properties

Creating new markets for magnet materials

- ✓ SmFeN, NdFeB, MnBi, MnAlC, and others.
- ✓ Hybrid compositions for achieving new magnet benefits.

Enabling reduced heavy rare earth content

- ✓ Engineering magnets that work around the need for HREE NdFeB.

Expanding possibilities with AI revolution

- ✓ AI and computing can discover new magnet materials – AML can enable these in practice.

	NdFeB	(Mm-Nd)FeB	SmFeN	MnBi
Magnet Material	Neodymium, iron, boron	Mischmetal (Ce, La, Nd), iron, boron	Samarium iron nitride	Manganese bismuth
Commercialization Customers	Existing NdFeB magnet users	Existing NdFeB magnet users	Motor & generator companies	Motor & generator companies
Key Ingredients[1]	Neodymium (30%) Iron (68%) Boron (1%) Other (Pr, Dy, Tb)	Neodymium (15–22%) Iron (68%) Boron (1.5%) Mischmetal	Samarium (23%) Iron (73%) Nitrogen (3%) Other (1%)	Manganese (50%) Bismuth (50%)
Value Propositions	New shapes beyond ‘block’ magnets	Lower cost; added traceability	No heavy rare earths	Rare-earth-free; replaces ferrite

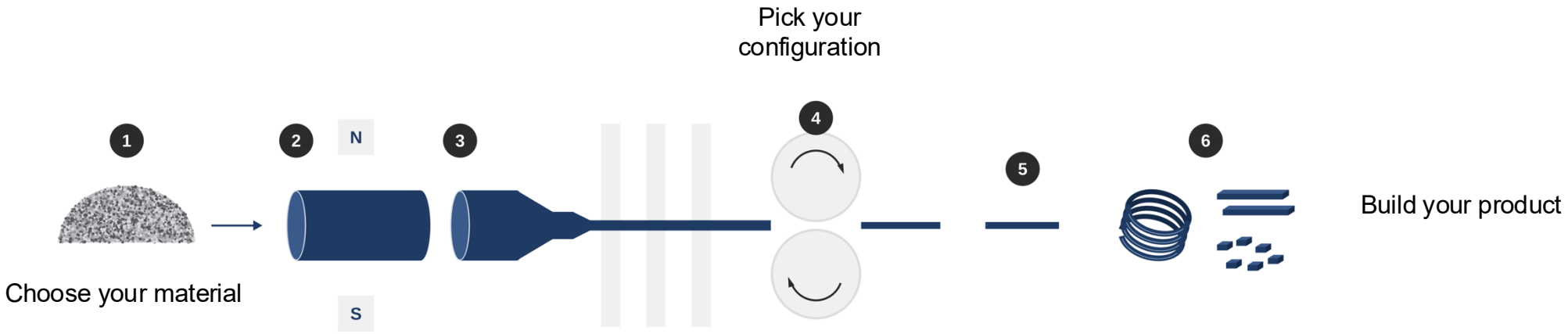
The spectrum of opportunity with PM-Wire™ enables both existing and new magnet materials.

[1] Ratios are estimates based on public information and subject to change or differing interpretation. NdFeB generally includes dysprosium and/or terbium for performance requirements.

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The PM-Wire™ Process

Continuous and controlled process for producing magnets



PM-Wire™ *powder in tube* **process**

(1) magnet powder (2) through (4) PM-Wire process; (5) cut to length; (6) final magnets.

AML's Process Benefits	Custom shapes	Strong magnets: no cracking, chipping, or corrosion	Custom magnetization directions	Continuous and automated by design

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Example Magnet Configurations

Innovative permanent magnet design, manufacturing, and application

PM-UNIFORM™

Straight, curved, ring or helical magnets with Transverse or Radial magnetization

Single-Piece Magnets

Straight over 1 m long

Curved

Rings

Helical

Lower Cost Assemblies

Reduced part count



*Non-sintered

PM-360™ - “Single-piece Halbach Array”

Straight, ring or helical magnets with “Continuously Changing Magnetization Direction”

Enhanced Field

Halbach Array Performance

Reduced Weight

Iron Free

Lower Cost Assemblies

Reduced part count

Ease of assembly



PM-AXIAL™

Curved magnets with Axial magnetization allow rotor topologies having breakthrough benefits

Increased Performance

Higher Operating Temperature

Reduced Overwrap

Reduced Weight

Iron Free

Lower Cost Assemblies

Reduced part count

Ease of assembly

Enables low coercivity materials



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Our Innovation - PM-Wire™ Magnets for Motors

Innovative permanent magnet design, manufacturing, and application

Why PM-Wire Magnets Matter

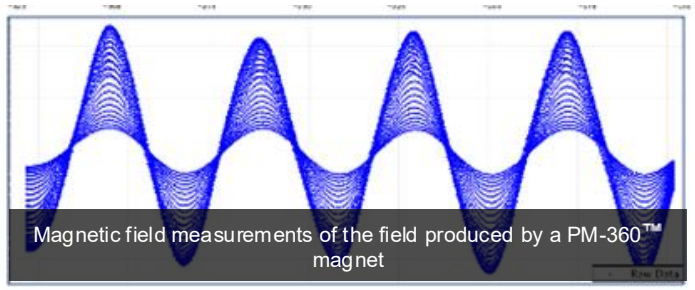
Flexibility in magnet shape and magnetization direction opens the design space for the applications and **smart design**:

Minimize demagnetization

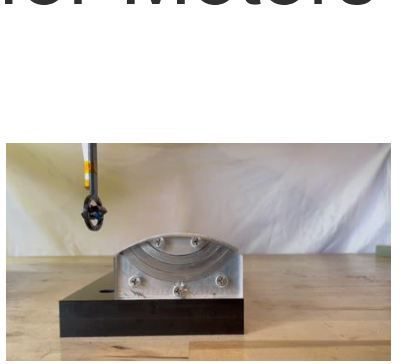
- Allows operation at higher temperatures
- Enables the use of lower coercivity magnets (**less REEs, nor Heavy REEs**)
- Enables new designs and topologies

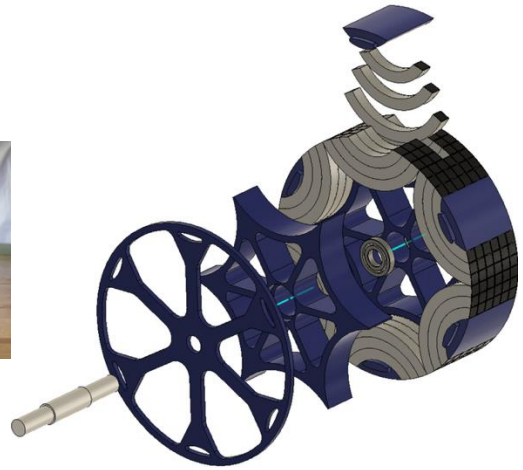
Generate multiple poles from single magnets

- Significantly reduce the number of parts/magnets
- Simplify assembly: no tooling needed
- Enhance the field magnitude
- Produce sinusoidal fields (no space harmonics)
- Enable the use of lower Br magnets

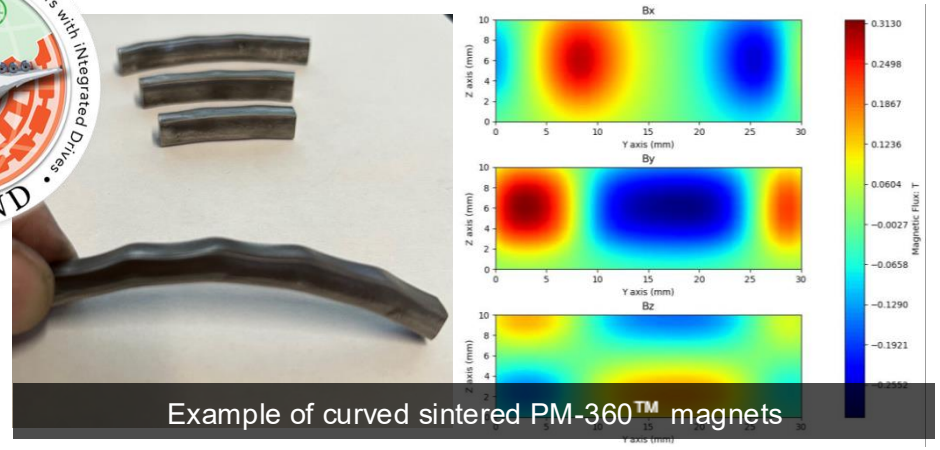


Magnetic field measurements of the field produced by a PM-360™ magnet





PM-Axial rotor configuration: demagnetization field < 0.15 T in the rotor magnets!



Example of curved sintered PM-360™ magnets

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Sintered PM-Wire™ Magnets

Performance qualification – in production and on the roadmap

	Grade	Br (T)	Hcj (kOe)	Max Op. Temp	Representative Use	Status
In Production	**N42–N48**	1.28–1.40	> 10	80 °C	General industrial motors and actuators	In production
	N42M	1.30	> 14	100 °C	Servo and small motors	In production
	N45SH	1.35	> 20	150 °C	Drone and small motors	In production
	N48H	1.40	> 17	120 °C	Servo and high-density industrial motors	In production
On Roadmap	**N52H**	1.45	> 17	120 °C	High-density drone motors	Q1 2027
	N48SH	1.40	> 20	150 °C	Drone and high-density motors	Q2 2027
	N48UH	1.40	> 25	180 °C	High-temperature defense motors	Q2 2027
	N35EH	1.15	> 30	200 °C	High-temperature defense motors	Q2 2027

PM-Wire™ Magnets

1″ × 1″ × 3″
Current max magnet size

2″ × 2″ × 5″
Target max magnet size

Axial or Transverse
Magnetization direction

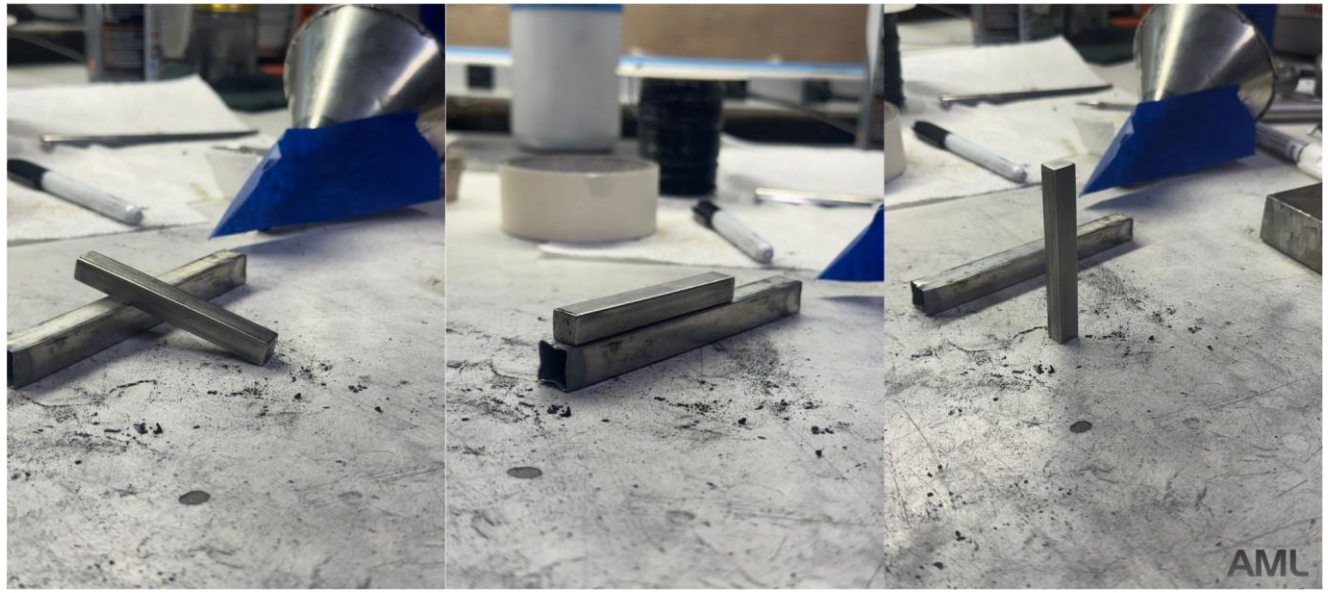
Finishing
Cutting and coatings

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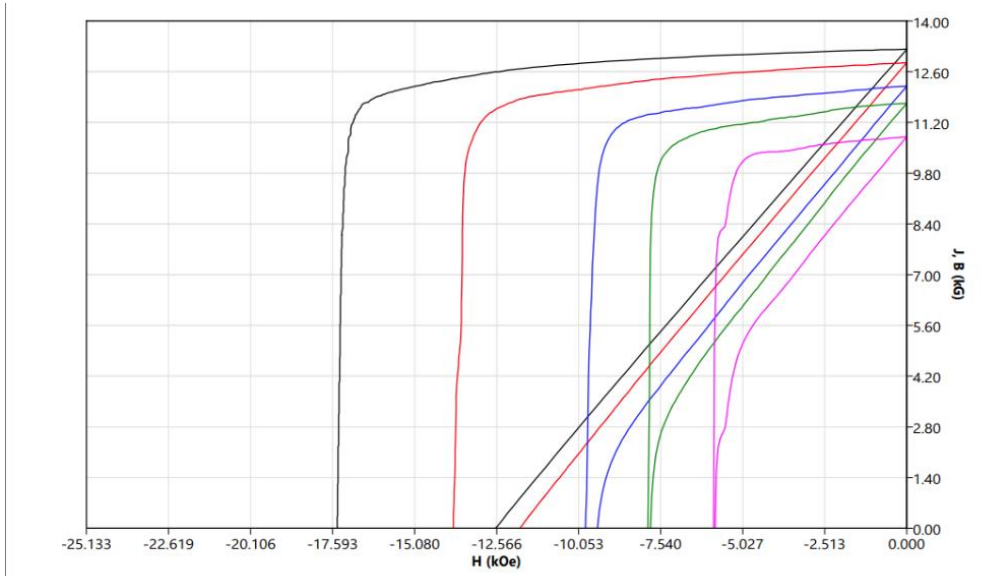
Sintered PM-Wire™ Magnets

Sintering performance matching traditional processes

Magnetic performance identical to CIP magnets



Example of PM-Wire magnets after sintering



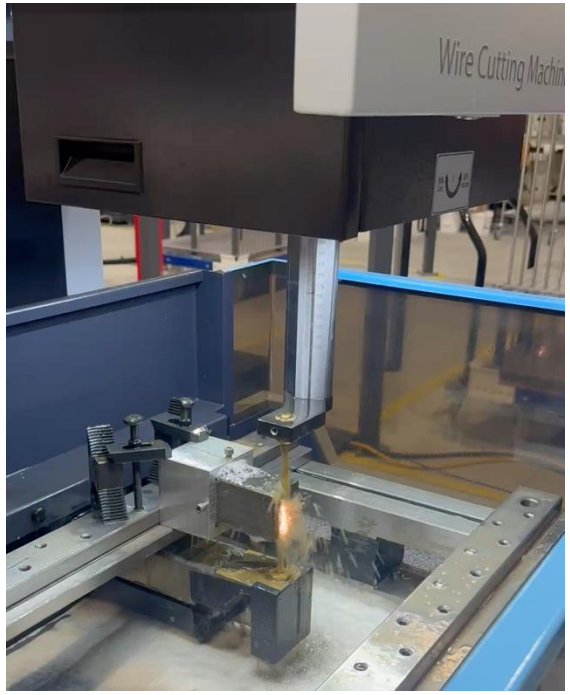
File	Sample	Material	Section shape	T (°C)	Br (kG)	HcB (kOe)	HcJ (kOe)	BHmax (MG·Oe)	BA (kG)	HA (kOe)	Hknee (kOe)
ASM_1080_Batch_8_RT	ASM_1080_Batch_8	NdFeB	Irregular	30.0	13.222	12.603	17.452	42.423	6.623	6.405	16.260
ASM_1080_Batch_8_60C	ASM_1080_Batch_8	NdFeB	Irregular	60.0	12.846	11.848	13.896	39.109	6.540	5.980	12.589
ASM_1080_Batch_8_100	ASM_1080_Batch_8	NdFeB	Irregular	100.0	12.200	9.475	9.842	34.322	6.232	5.507	8.956
ASM_1080_Batch_8_120	ASM_1080_Batch_8	NdFeB	Irregular	120.0	11.726	7.846	7.926	30.888	5.955	5.187	7.185
ASM_1080_Batch_8_150	ASM_1080_Batch_8	NdFeB	Irregular	150.0	10.804	5.870	5.916	26.433	5.720	4.621	5.266

Example of demagnetization curves of PM-Wire magnets

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PM-Wire™ NdFeB Magnets for Drone Motors

Enabling advanced manufacturing for drone motor applications







U.S.-made magnets for U.S. drones

Finishing for drone motors

Sintered NdFeB magnet finishing for challenging applications such as drone motors.

Near-net shape

The PM-Wire™ process adapts to near-net-shape magnets that are easier to cut.

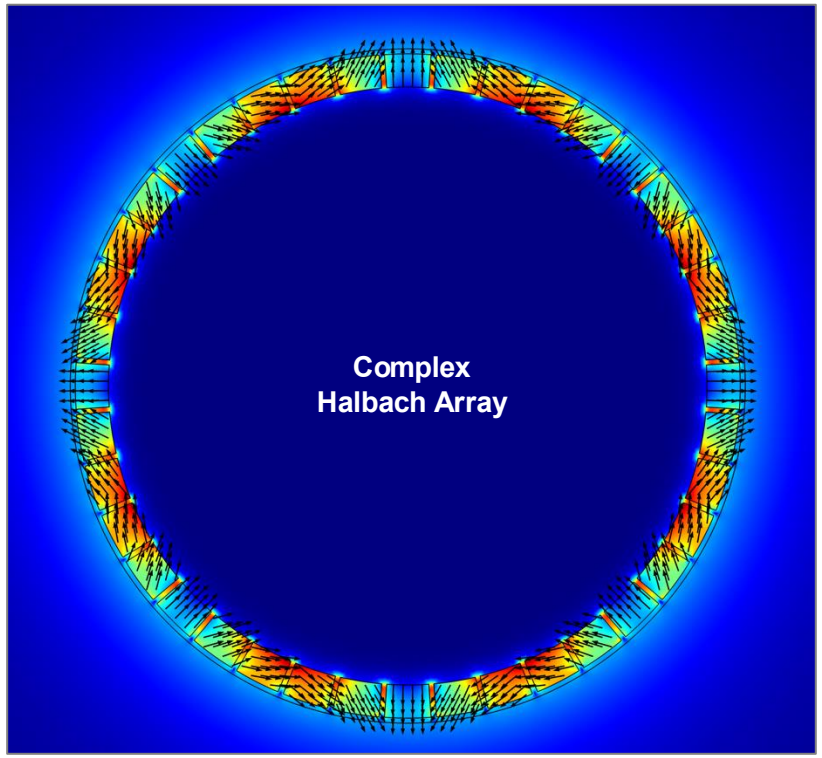
PM-Wire™ magnets are produced with the desired cross-section, allowing for a (near) single cut per magnet.

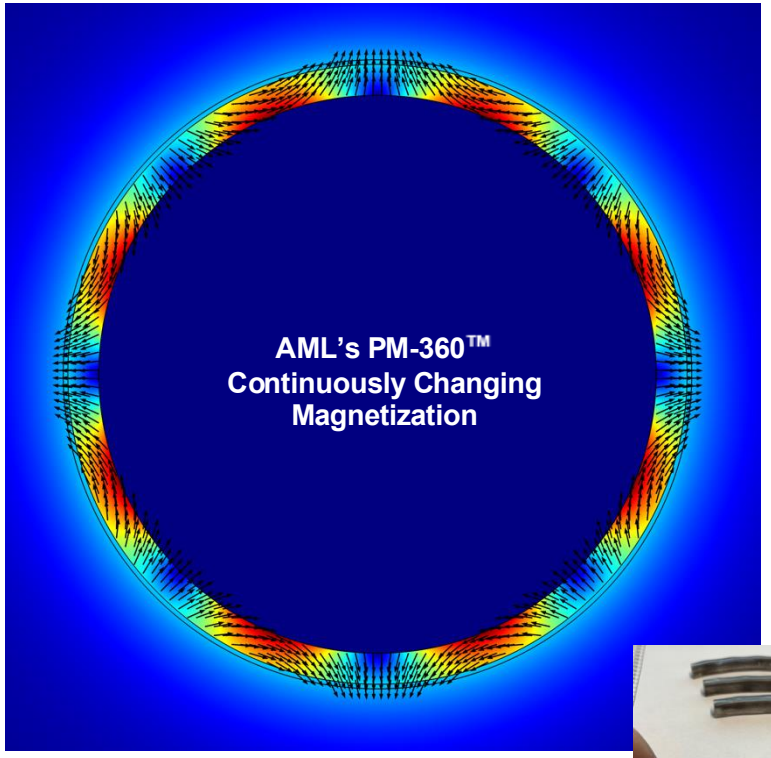
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PM-360™ Magnets - Continuous “Halbach Arrays”

A new frontier for innovative permanent magnets

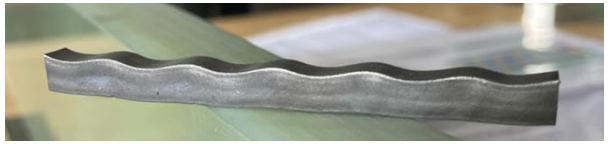
Single-piece, ring and helix “Halbach Array”



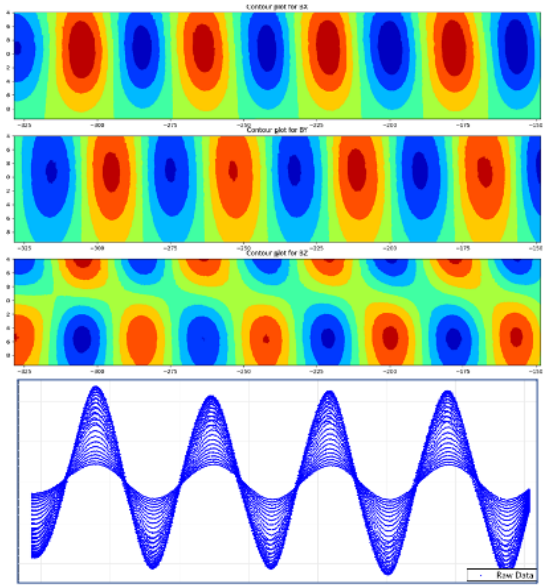




NdFeB PM-360™ magnets



NdFeB PM-360™ magnet



PM-360™ 3D Field Map - Sinusoidal Magnetic Field Distribution

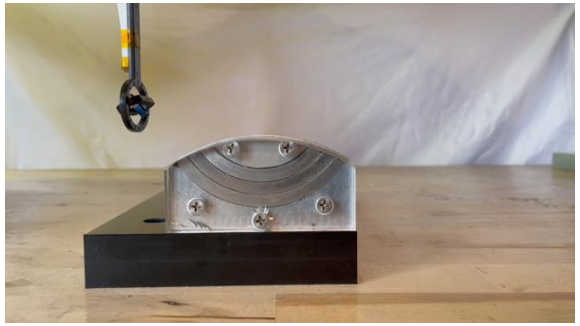
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PM-Wire™ - Material Enabler with Unmatched Flexibility

Examples of innovative design with a wide array of magnet materials

Materials

- ✓ SmFeN
- ✓ NdFeB
- ✓ MnBi
- ✓ Other



PM-AXIAL™ Magnets



PM-UNIFORM™ Magnets



PM-360™ Magnets



Engineering magnets

- ✓ Custom shapes
- ✓ Custom magnetization direction
- ✓ Strong: strength of Stainless steel
- ✓ No cracking, no chipping
- ✓ No corrosion (magnets sealed in jacket)



PM-360™ Radial Flux Rotor



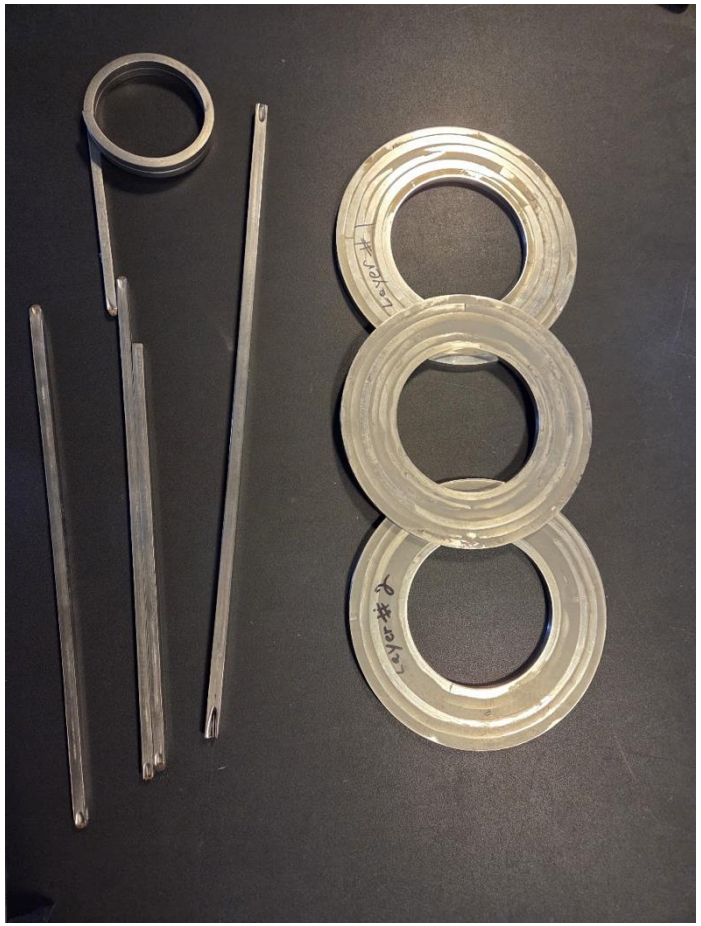
PM-360™ Outrunner Rotor



PM-360™ Axial Magnetization

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Example PM-Wire™ SmFeN Magnets



SmFeN

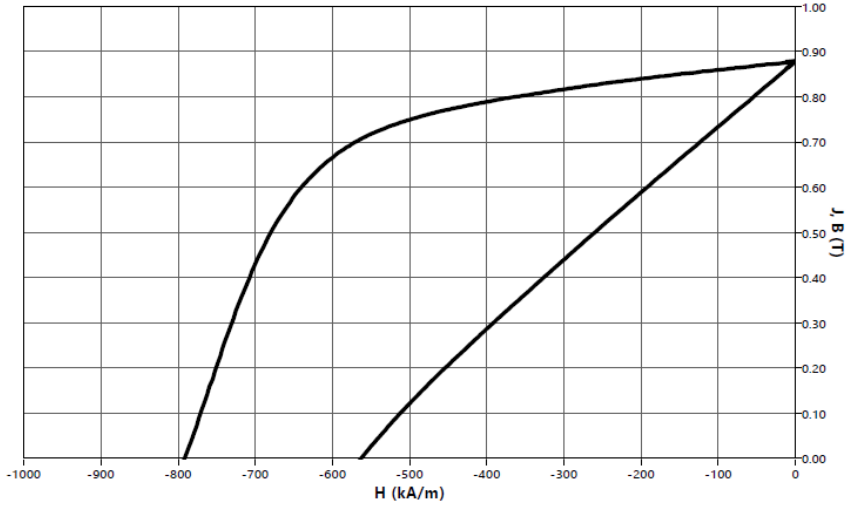
- ✓ Br = 0.88 T
- ✓ Hcj = 10 kOe
- ✓ BHmax = 16.5 MGOe
- ✓ Density = 6000 kg/m^3

Temperature coefficients:

- ✓ α = -0.035 %/C
- ✓ β = -0.55%/C

File	0400
Date and time	07-05-2025 11:22
Sample	0400
Material	Bonded neodymium
Section shape	Circle
Diameter	10.00 mm
Thickness	11.30 mm
Section area	78.54 mm²
Measuring coil	LJT10, SN T1481
NB	83.79
NxA	8801 mm²
Range flux H	10
Range flux J	5
Poles	LP-60
Type of measure	I° and II° quadrant
Max applied field	397.89 kA/m
Max demag field	Automatic
Delay	0.50 s

Temperature	20.0 °C
H max	(449.4 ± 6.7) kA/m
J max	(0.917 ± 0.009) T
B max	(1.482 ± 0.015) T
Br	(0.878 ± 0.009) T
HcB	(562.7 ± 8.4) kA/m
HcJ	(791.7 ± 11.9) kA/m
BHmax	(131.95 ± 2.64) kJ/m³
BA	(0.449 ± 0.004) T
HA	(293.9 ± 4.4) kA/m
Hknee	(395.5 ± 5.9) kA/m
JHmax	(400.48 ± 8.01) kJ/m³
Initial slope	1.156 ± 0.023
Area J	(578.10 ± 11.56) kJ/m³
Demag. factor	0.28
Hd	190.3 kA/m
Jd	0.841 T



Typical demagnetization curve for non-sintered SmFeN PM-Wire™ magnets

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PM-Wire™ SmFeN Magnets – Drone Motors

Innovative manufacturing with PM-Wire™ – powder-in-tube process

We demonstrated that SmFeN can replace NdFeB in drone motors.

- ✓ No blocks to cut, no wasted material.
- ✓ No cracking, no chipping, no corrosion.

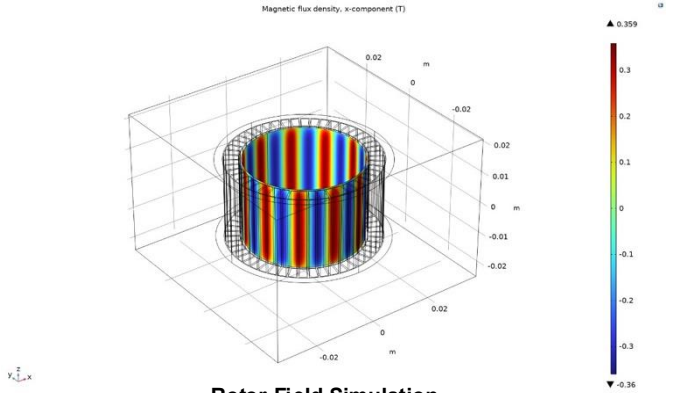
An affordable Halbach array that delivers performance equivalent to sintered surface-mounted magnets.

Reduced space harmonics in the field, reduced cogging torque.





SmFeN rotor during assembly



Rotor Field Simulation

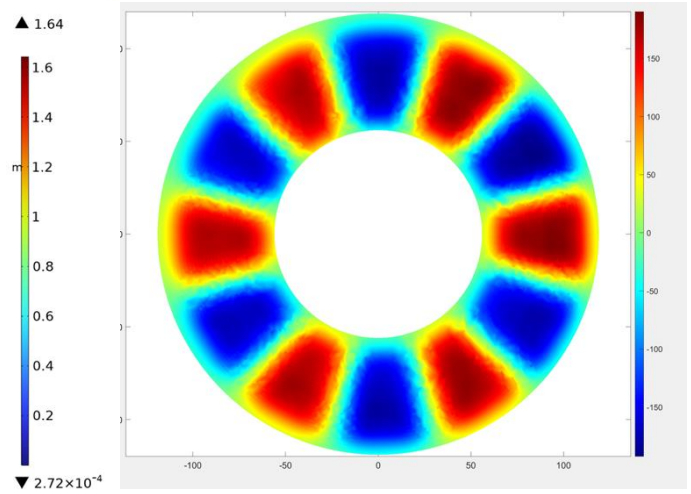


Motor testing

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PM-Wire™ SmFeN Magnets – Axial Flux Motors

Problem	High-dynamics axial flux permanent magnet motors with reduced space harmonics for precision motor applications.
Solution	**PM-360™** ✓ Retrofit solution: replacing NdFeB surface-mounted magnets with SmFeN PM-360™ magnets ✓ 18 rings, 12 poles
Impact	✓ Purely sinusoidal airgap flux density ✓ Smooth torque with no cogging ✓ Easier assembly and lower manufacturing cost ✓ Enables precise motor control



Measured field map - PM360™ axial flux Rotor



PM-360™ rotor assembly – magnetic paper showing the magnetic poles

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PM-Wire™ SmFeN Magnets – Axial Flux Motor

3rd Motor Dynamic Testing

- ✓ Axial flux motor
- ✓ 12 poles
- ✓ 22 cm rotor OD
- ✓ PM-360™ SmFeN magnets

Larger Motors in Development

- ✓ Over 75 cm rotor OD
- ✓ High-precision motors
- ✓ Torque density equivalent to a surface-mounted NdFeB magnet rotor



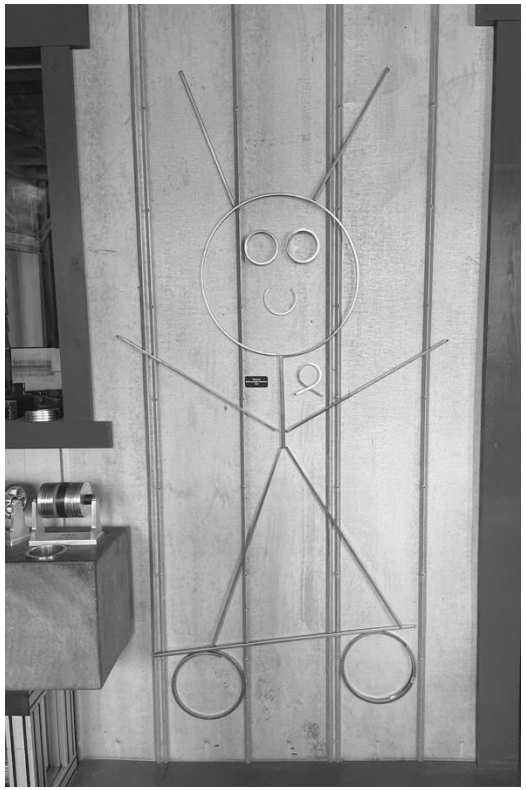
Rare Earth Mines, Magnets & Motors 2026, Sept. 30th, 2026 - Advanced Magnet Lab, Inc. All rights reserved worldwide.

What does the future hold?

REE supply partnerships
Let's build a diversified globally supply chain for value-add magnet products

Let's build better products with magnets
Innovation for improved applications through smart magnet designs

Enabling new magnet materials for a tech revolution
AML is leading the transition to non-REEs and new materials for applications



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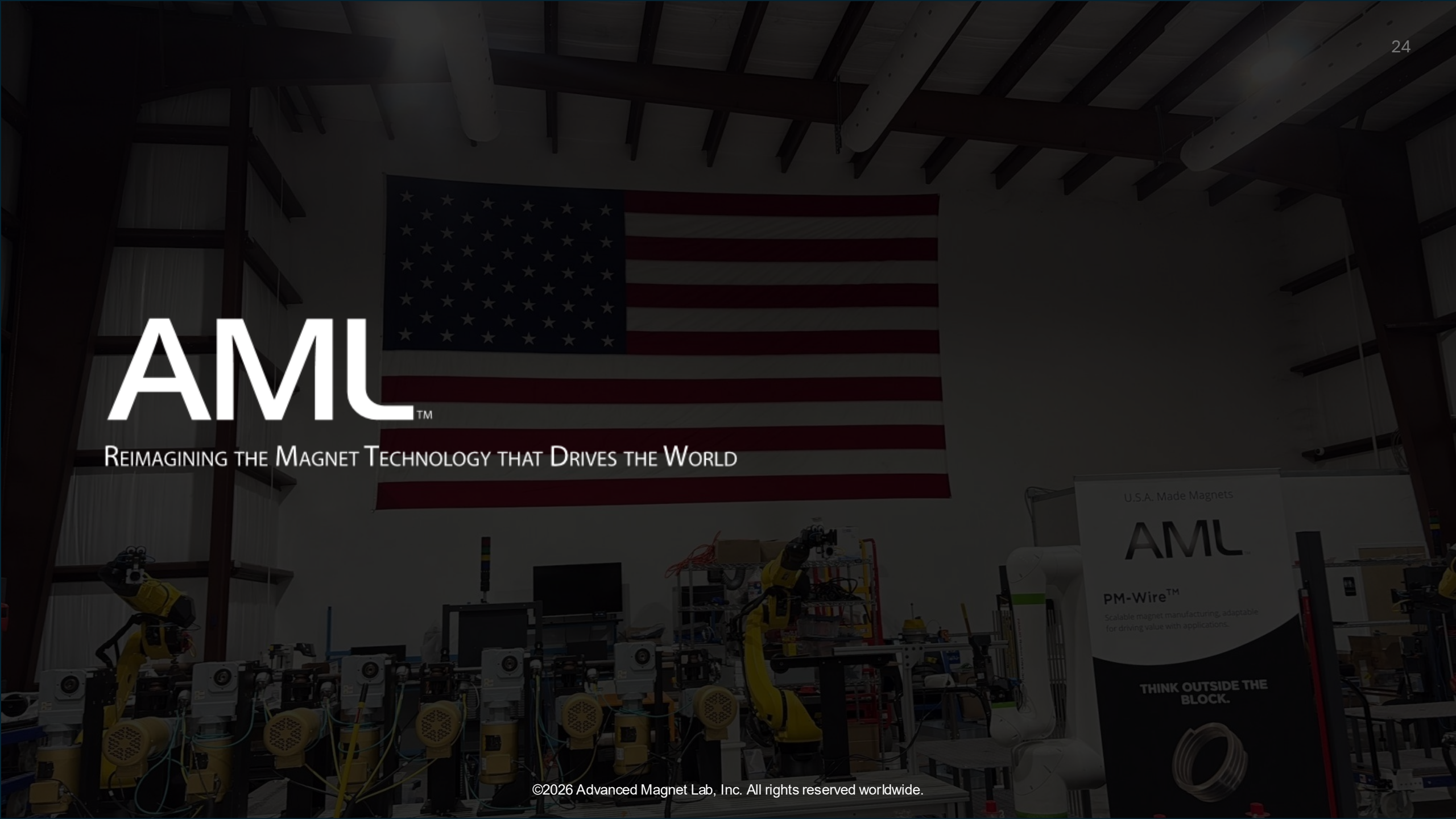
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Something big is coming…

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