



Reimagining the Magnet Technology that Drives the World

PM-Wire™ Magnets: Thinking Outside the Block!

Advanced Magnetics & Manufacturing

General Presentation for Public Distribution

World-Class Magnet Technologies

AML was founded on principle of developing world-class magnet technologies that solve complex application needs.

- ✓ Significant IP and software portfolio, trade secrets, and knowhow for designing and producing permanent magnets.

Magnet Technologies + Advanced Manufacturing

AML combines its magnet innovation with advanced manufacturing capabilities.

- ✓ AML's team has decades of experience with advanced manufacturing solutions, including leading significant growth transitions.

Funded to Scale – \$15M to date

AML has contributed \$8.5M along with \$1M from strategic sources combined with \$5.5M from the U.S. federal government towards commercialization.

- ✓ AML has drawn significant interest from the REE supply chain, private investors, and the federal government to solve the magnet problem.



**AML facilities located on Florida's Space Coast
Melbourne, Florida**



**AML expansion plans include additional facilities
in Florida and co-location with strategic partners**

Management



Wade Senti, President, Director

- Lead all of AML's major transactions and supported \$10M + 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) from the University of Florida.



Philippe Masson, Chief Technology Officer

- Co-inventor of most of AML's game-changing permanent magnet technologies and responsible for leading AML technology development and customer programs.
- 20+ years of experience developing superconducting applications and permanent magnet technologies.
- Ph.D. in Electrical Engineering from the Université Henri Poincaré, Nancy, France.

Board of Directors



Mark Jensen

- Entrepreneur and businessperson who has founded several companies.
- Chairman and CEO of American Resources Corporation (NASDAQ: AREC) a next generation producer of raw materials.
- Mr. Jensen previously held positions in the financial services and investment sector.



Bill McCollum

- Dentons, Partner - Public Policy and Regulation.
- Former Florida Attorney General.
- Retired U.S. Congressman.
- Retired commander in the U.S. Naval Reserves.



Raj Gutta

- Serial entrepreneur, investor, and medical doctor.
- University of Michigan undergrad and medicine.



Tom Turner

- 40+ years developing, operating and exiting high-tech businesses.
- Companies included Wang Canada Limited, Datamax Corp. and Itronix.
- Currently active in a number of early-stage companies and a partner / developer of a new sustainable City in Costa Rica.



Marshall Heard

- The Boeing Company (ret.), Ran a \$4B Division.
- Engineering, product development, and operations.
- Air Force Strategic Air and Systems Command.



Vernon Prince

- 30 + years, entrepreneur, executive
- Multiple advanced manufacturing operations
- Luminar Technologies, JDS Uniphase
- Founded/Exited - OPA

U.S. Department of Energy / ARPA-E ASCEND

- ✓ **2021 – 2025:** Project Title: “High Power Density Dual-Rotor Permanent Magnet Motor with Integrated Cooling and Drive for Aircraft Propulsion.”
- ✓ Patented dual-rotor based on non-sintered PM-Wire™. Specifications provided by large U.S. aerospace and defense company.
- ✓ Program objective – develop magnet and stator technology for lightweight and efficient all-electric powertrain that would help enable net-zero carbon emissions in single-aisle 150-200 passenger commercial aircraft.

U.S. Department of Defense / Defense Innovation Unit

- ✓ **2020 – 2022:** Provided funding for the design, build and commissioning of innovative Pilot Manufacturing Process.
- ✓ Program objective – design, build and initial commissioning of an advanced PM-Wire™ Pilot Manufacturing Line for production of non-sintered magnets.

U.S. Defense & Aerospace Company

- ✓ **2020 – Present:** Provided funding for expanded development work with AML’s magnet technology and partnered on application development.
- ✓ Development work led to magnets with “continuously changing magnetization direction” (single-piece Halbach array) using bonded NdFeB material compositions.
- ✓ New collaborations for sintered magnet innovation around AML PM-360 technology for developing and refining manufacturing process.

U.S. Department of Defense / Defense Logistics Agency

- ✓ **2022 – Present:** Project Title: “Development and Qualification of Domestically Sintered Neodymium Iron Boron (NdFeB) Magnets for Weapons Platforms.”
- ✓ The objective was to qualify sintered PM-Wire™ magnets and to design, build and commission advanced manufacturing for sintered PM-Wire™.
- ✓ Program objective – develop sintered PM-Wire™ magnet configurations using NdFeB compositions – acquisition of equipment and facilities upgrades.
- ✓ Other Collaborations: qualification of sintered magnets for defense and supply chain integration for a domestic supply chain for defense.

U.S. Naval Nuclear Laboratory

- ✓ **2021 - Present:** Designed, commissioned and tested and superconducting / permanent magnet bearing system and other work and projects related to permanent magnets applications and sourcing/qualification.

Applications development – We’ve done 100s of design studies to date

Motor and Generator Applications

AML is working with major motor and generator firms to unlock new performance value and smart supply chain strategies.

Consumer Electronic Applications

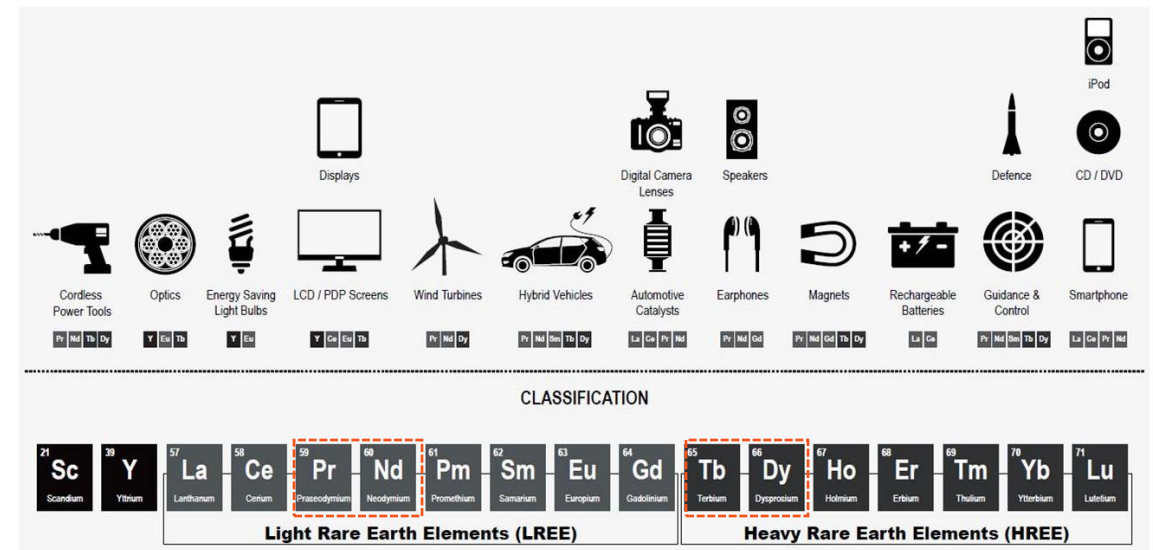
Data storage and other emerging applications are driven by the AI and quantum revolution – need for alternatives is a rapidly growing market.

Defense and Aerospace Applications

AML is engaged with firms developing motor and generator applications for defense.

Other Applications

Medical, robotics, automotive, and others.



Source: China WaterRisk report, "Rare Earths: Shades Of Grey – Can China continue to fuel our clean and smart future?" (June 2016)



We are working to remove the constraints of a Neodymium, Praseodymium, Terbium and Dysprosium driven magnet supply chain.

What separates AML from the rest?

To compete in the United States with global market – you must be able to produce high volume, cost-competitively, and add product value. **AML can do all three.**

Ideal magnetic distribution, single-piece “Halbach Arrays”, long-lengths with the ability to design in shapes and curvatures that provide applications expanded benefits, including building a magnet around less REE (or non-REE) material attributes.

	AML	Other Magnet Mfg's
Magnet design	Shapes, sizes, lengths, different magnetizations	Block magnets, magnetized in one direction
Equipment & Capabilities	Automated by design, incorporating standard equipment	Standard equipment for sintered manufacturing with some automation
Manufacturing Processes	High-rate, high yield, automated by design, flexible, and lower capex	Laborious, rigid, non-interchangeable, higher capex
Supply Chain	All magnet materials REE, Non-critical REE, REE-Free	REE - Neodymium Iron Boron REE – Samarium Cobalt
	 AML PM Magnets	 Conventional Sintered Magnets

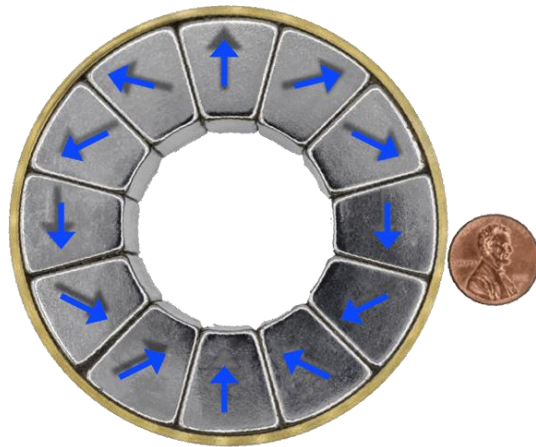
The Industry Today – NdFeB Sintered Magnets

Other Magnet Manufacturers

AML

NdFeB are usually produced as uniformly magnetized blocks.

- ✓ Magnets need to be cut from blocks
- ✓ Designers are limited to small magnets with single magnetization directions
 - Design space constraints for the applications
 - Need to combine multiple magnets to achieve variable magnetization directions (expensive tooling)
 - Need high-grade magnets to prevent demagnetization
- ✓ “Single size” fits all approach



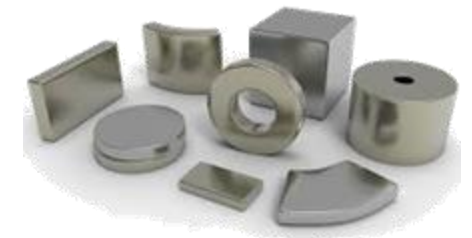
Halbach array composed of uniformly magnetized blocks



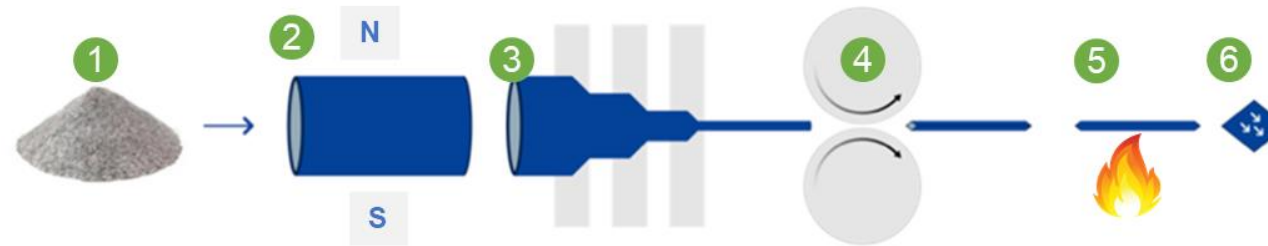
Synchronous motor rotor with surface-mounted magnets



Magnet blocks during manufacturing



COTS magnets



- (1) Powder is placed in a cylindrical or square tube**
- (2) Powder is pre-aligned using a magnetic field**
- (3) Filled tube is sized, leading to compression and cross-section reduction**
- (4) Swaging, rolling to further reduce cross-section, increase density, and obtain the desired shape**
- (5) Sintering-Annealing-Aging cutting, grinding, coating**
- (6) Final magnetization**

PM-Wire Magnet Manufacturing



Example of High-Rate Magnets Production Line
Partially funded by U.S. Department of Defense / Defense Innovation Unit



Sintering furnace



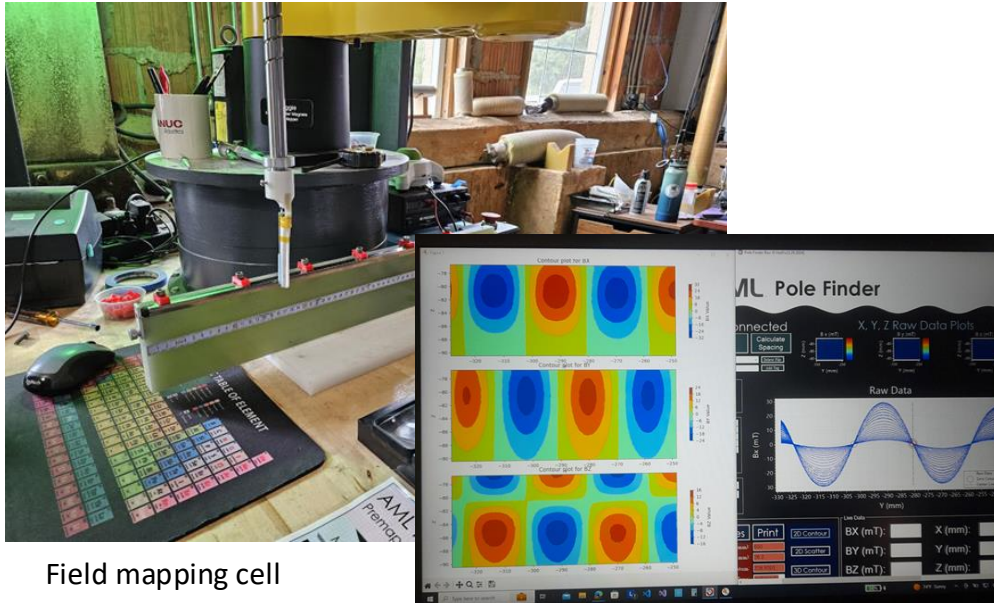
E3 Automated Tube filling in inert environment
Partially funded by U.S. Department of Defense / Defense Logistics Agency



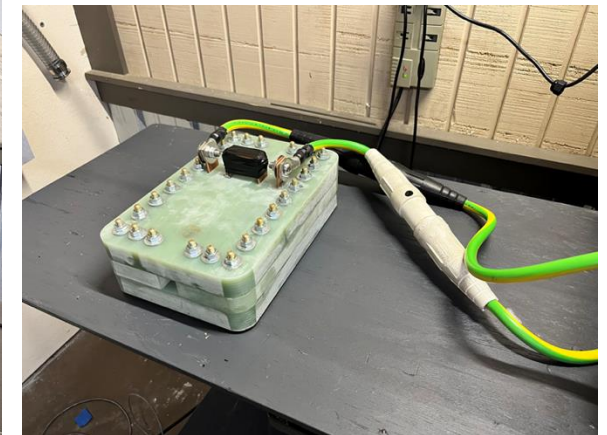
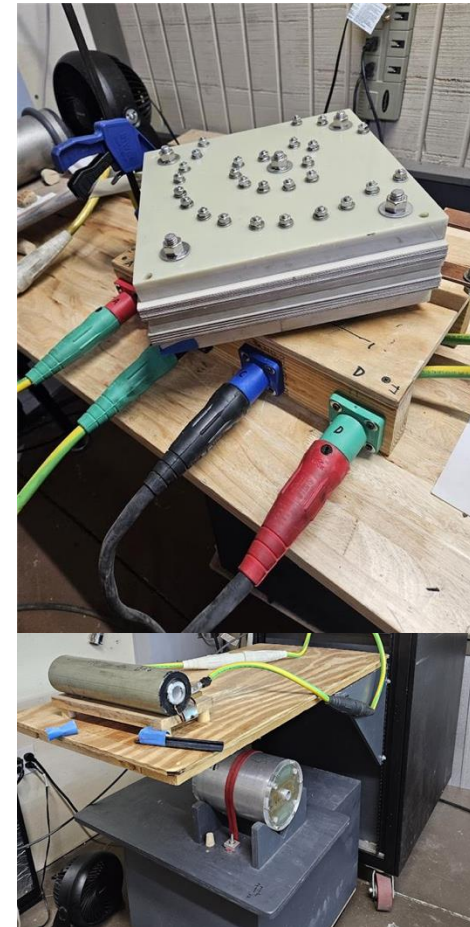
Sintered Magnets Lab
Partially funded by U.S. Department of Defense / Defense Logistics Agency

AML has developed custom pre-alignment and magnetization fixtures to achieve useful magnetization configurations

- ✓ Axial for straight and curved magnets
- ✓ Radial for rings and curved magnets
- ✓ Uniform for long straight magnets and large blocks
- ✓ PM-360 (single piece multipole)
 - Radial inward and outward flux
 - Axial flux



Field mapping cell



Example of custom magnetization fixtures

Only 1 step requires an inert environment

Flexible shapes

- ✓ Long straight magnets
- ✓ Curved magnets

Flexible magnetization directions

- ✓ Radial
- ✓ Axial
- ✓ Continuously changing (PM-360™)

Opens the design space for applications

- ✓ Applications no longer constrained to small uniformly magnetized block magnets

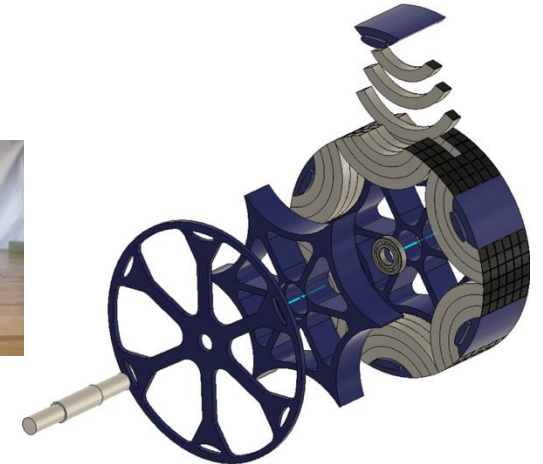
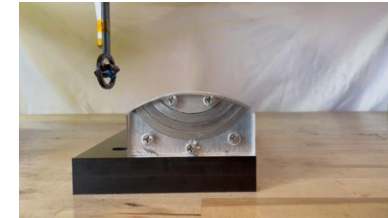


6-pole single-piece NdFeB magnet (PM-360™)

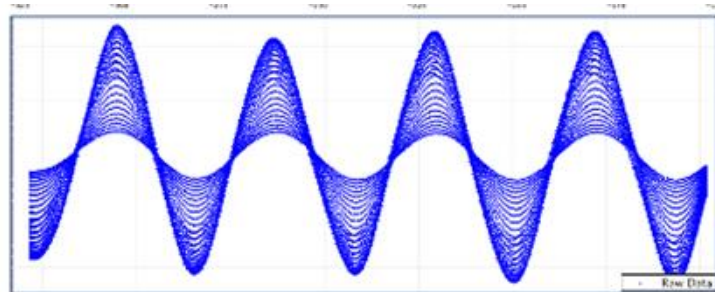


Flexibility in magnet shape and magnetization direction opens the design space for the applications and smart design:

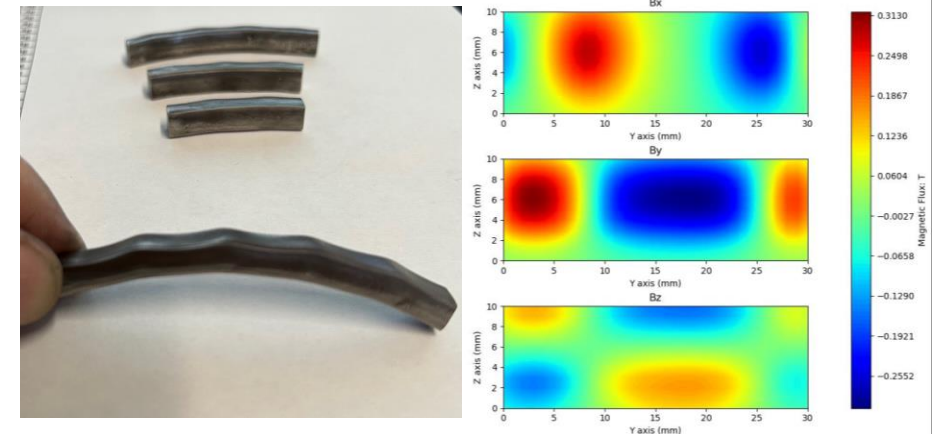
- ✓ Minimize demagnetization
 - Allows operation at higher temperatures
 - Enables the use of lower coercivity magnets (less REEs, nor Heavy REEs)
 - Enables new designs and topologies
- ✓ Generate multiple poles from single magnets
 - Significantly reduce the number of parts/magnets
 - Simplify assembly: no tooling needed
 - Enhance the field magnitude
 - Produce sinusoidal fields (no space harmonics)
 - Enable the use of lower Br magnets



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



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



Example of curved sintered PM-360™ magnets

Example of Use of PM-Axial™ Magnets – Global Electrical Machine Manufacturer **AML**

Baseline Design

Torque - 311 Nm; Efficiency - 98.6%; Power - 375 kW; RPM - 11,500

Magnet Material: N48SH NdFeB

Maximum Operating Temperature: 100 C

Critical REEs: **NdPr** and **Dysprosium**

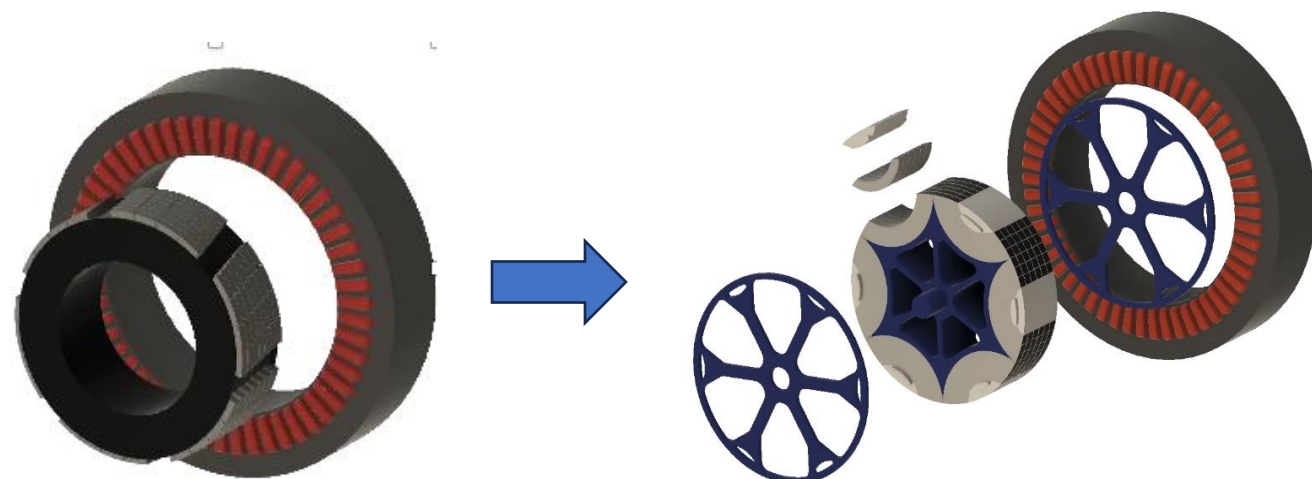
PM-AXIAL™ Impact – Significant Improvement In Performance

Solution

- ✓ Retrofit solution replaced conventional surface-mounted magnets topology with PM-AXIAL™
- ✓ No change to stator
- ✓ Same magnet N48SH NdFeB alloy

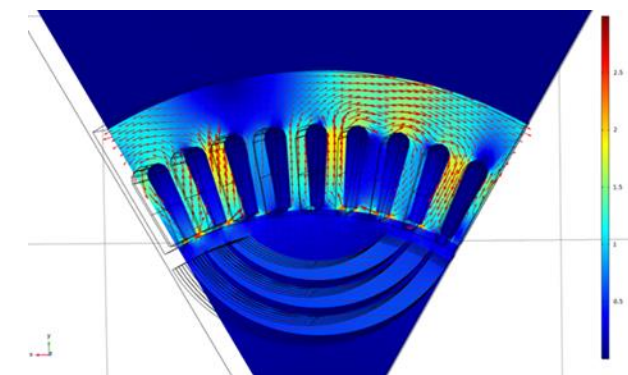
PM-Axial™ Performance Improvement

- ✓ Field enhancement
- ✓ Increase in operating temperature to over 150 C
- ✓ Reduction in rotor overwrap thickness
- ✓ 20% reduction in mass by removing the iron



Baseline Design – Conventional north-south pole rotor configuration

PM-AXIAL™ - Provides very-low demagnetization field (~ 1/10 of conventional north-south pole configuration)



Magnetic field distribution in 1 pole of the motor

Example of Use of PM-Axial™ Magnets – Global Electrical Machine Manufacturer **AML**

PM-AXIAL™ Impact – Reduced Critical REE

Solution

- ✓ Retrofit solution replaced north-south rotor pole topology with PM-AXIAL™
- ✓ No change to the stator
- ✓ **(Mischmetal / NdPr) NdFeB** alloy
 - Br and Hci (@ 120 C) = 1.01 T and 2.85 kGauss

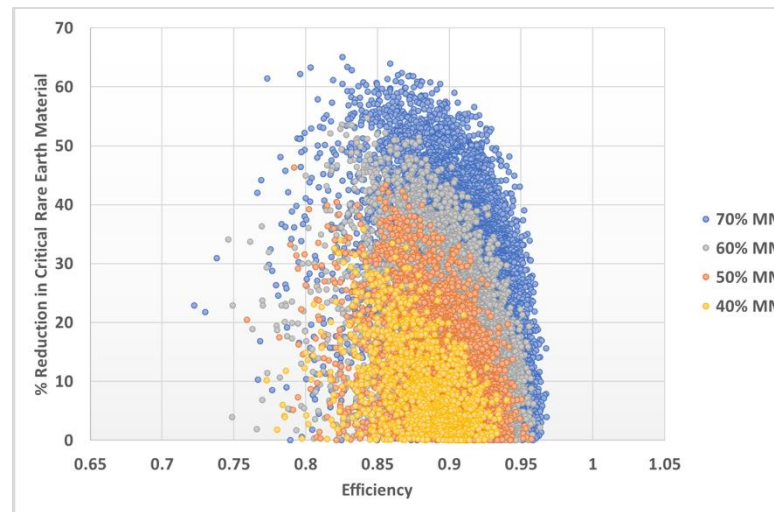
NdPr - ~ + \$80 per kilogram

Mischmetal - \$lower per kg
(Cerium, Lanthanum, Neodymium, Praseodymium)

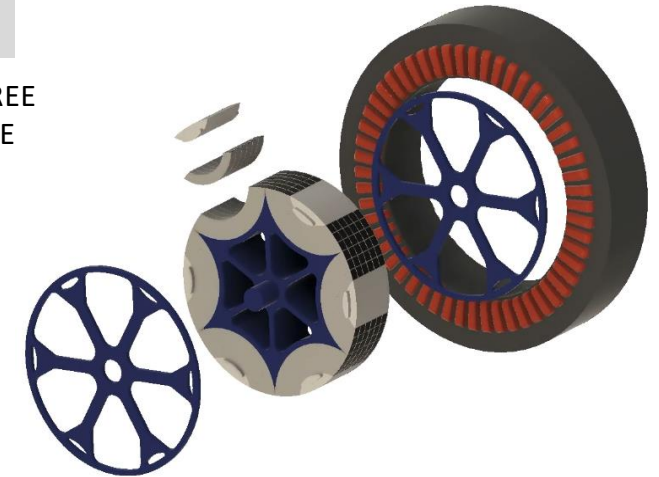
Mischmetal reduces the cost of REE separation and can provides REE provenance of NdPr oxides

PM-Axial™ Performance

- ✓ Equivalent torque and efficiency
- ✓ 37% reduction in critical REE (**NdPr**) and **no dysprosium**
- ✓ 11% reduction in active mass



Example of Reduction in critical REE materials vs. efficiency



PM-AXIAL™ - Provides very-low demagnetization field (~ 1/10 of conventional north-south pole configuration)

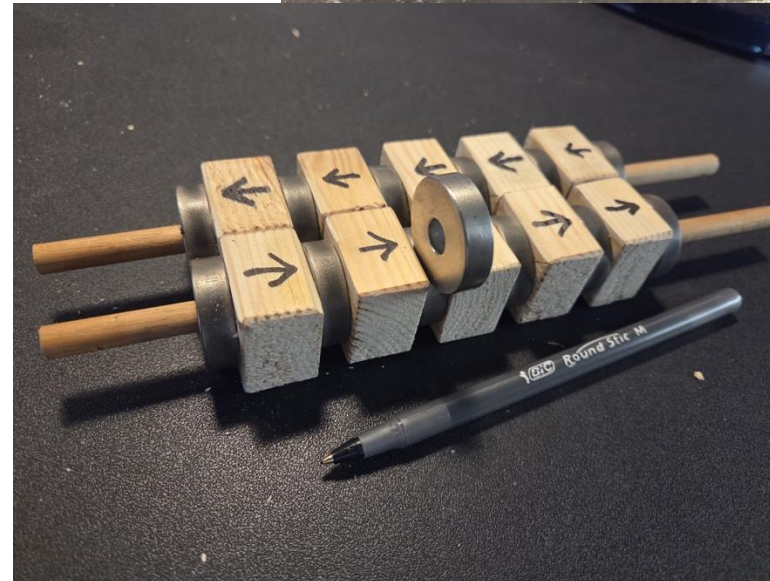
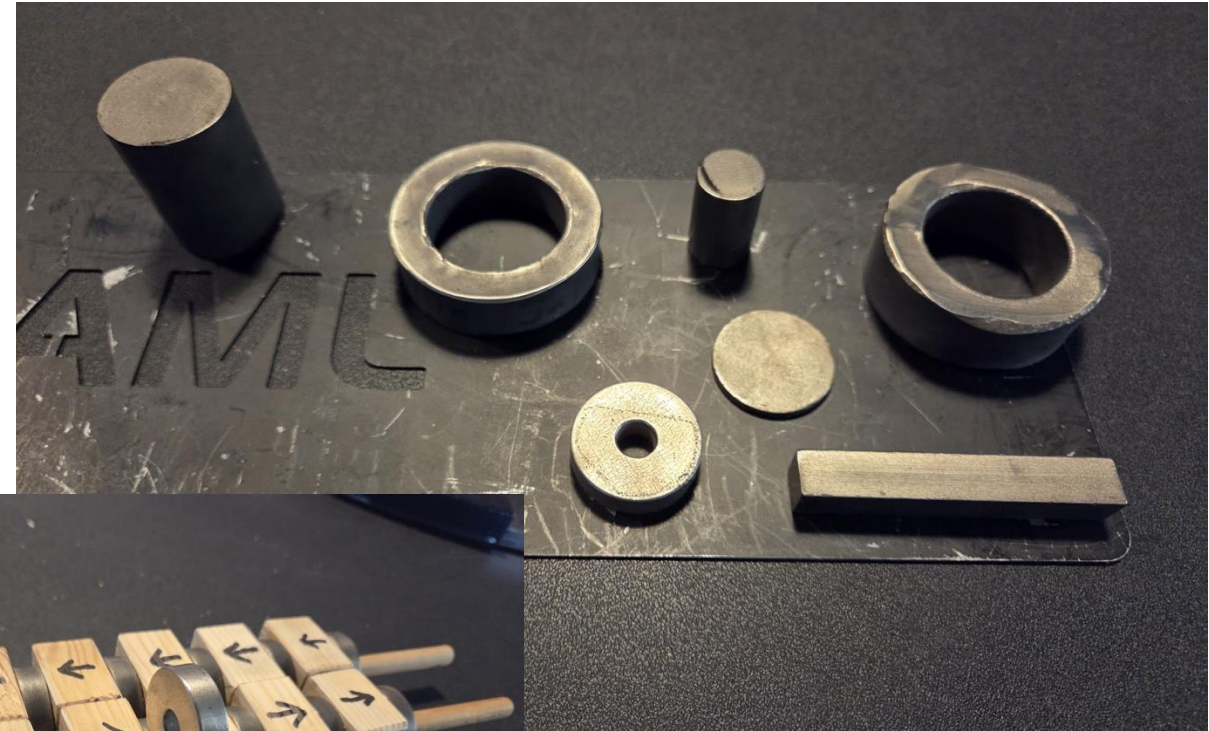
Conventional magnet shapes

- ✓ Blocks, cylinders, “donuts”, rings

Uniform magnetization

- ✓ Radial
- ✓ Axial
- ✓ Transverse

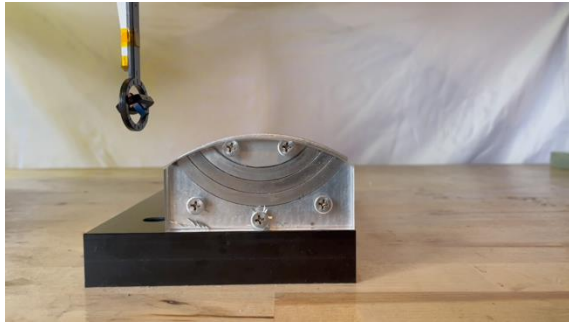
Produced in long lengths close to final cross-section or close to final shape



Example of different sizes and shapes NdFeB magnets produced at AML

Materials

- ✓ SmFeN
- ✓ NdFeB
- ✓ MnBi
- ✓ MnAlC
- ✓ FeN
- ✓ Other



PM-AXIAL™ Magnets



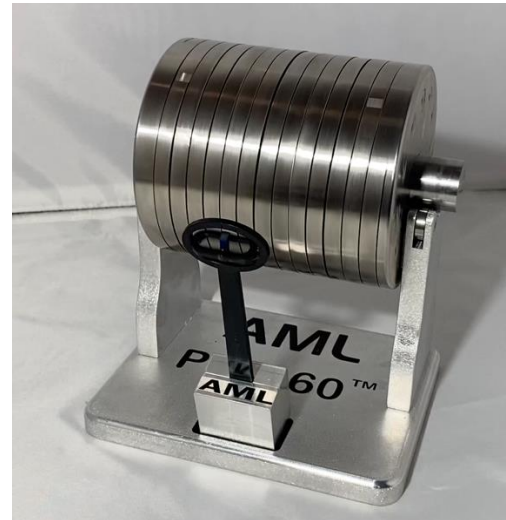
PM-UNIFORM™ Magnets



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

Example of PM-360™ Applications in Motors

AML

Motor Specifications

Collaboration with the Oak Ridge National Laboratory

U.S. Department of Energy: Power - 58 kW; RPM - 20,000

PM-360™ Impact – EV Motor With Non-Sintered Alloy

Solution

- ✓ Retrofit solution replacing Halbach rotor topology with PM-360™
- ✓ Replacing ~2,750 NdFeB thin sintered magnets with **8 PM-360™ rings**
- ✓ **SmFeN**
 - Br and Hci (@ 80 C) = 0.9 T and 14 kOe

PM-360™ Performance

- ✓ Equivalent torque and efficiency
- ✓ Significantly reduce part count and complexity of assembly
- ✓ Lower eddy current losses
- ✓ A fraction of the cost compared to sintered complex Halbach array design

PM-360™ Impact – Enable the use of SmFeN

Torque - 311 Nm; Efficiency - 98.6%; Power - 375 kW; RPM - 11,500

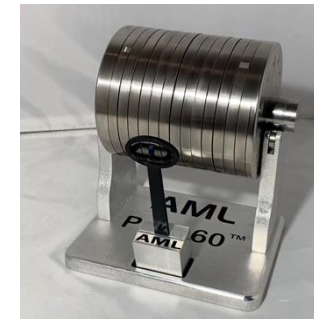
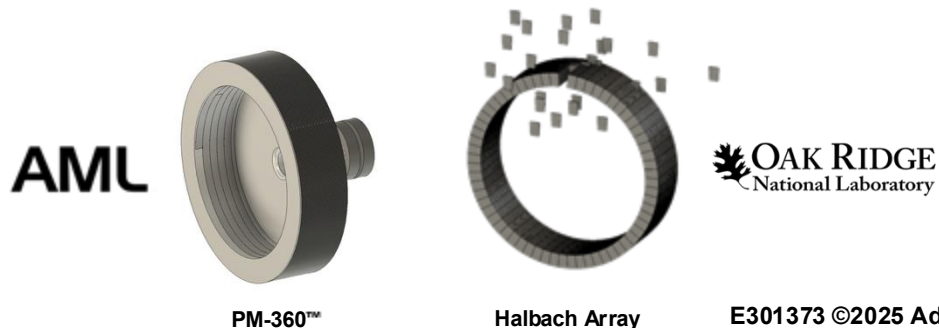
Maximum Operating Temperature: 100 C

Solution

- ✓ Retrofit solution replaced north-south rotor pole topology with PM-360™
- ✓ No change to motor stator
- ✓ **No Critical REE - Samarium Iron Nitride (SmFeN) alloy**
 - Br and Hci (@120C) = 0.88T and 11.5 kGauss @120C
- ✓ Replace 168 sintered N48SH magnets with **10 PM-360™ rings**

PM-360™ Performance

- ✓ Equivalent torque and efficiency
- ✓ 10% reduction in active mass
- ✓ No NdPr or Dy



PM-360™ - Helical



PM-360™ - Ten (10) Helical Rings replacing 168 sintered magnets

Qualification of “Non-Sintered” PM-360™

AML

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

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

Materials

NdFeB – NeoMagnequench, Aichi Metals

SmFeN – Sumitomo Metal Mining, Nichia

MnBi - AML

Lower Cost Assemblies

Reduced part count

Easy to assemble

Stability

Tube filled in an inert environment: the powder is sealed in tubes before compaction: → No Corrosion

Mechanical strength of Stainless Steel

Magnets can deform without cracking or breaking

Magnets cannot chip

PM-Wire process ideal for mass production



Example of PM-360™ Magnet assembly for axial flux motor.



PM-360™ Motor during testing

AML is spearheading several supply chains driven by customer demand

	NdFeB	SmFeN	MnBi
Magnet Material	Neodymium, Praseodymium, Iron, Boron	Samarium Iron Nitride	Manganese Bismuth
Commercialization Customers	Existing magnet market users	Motor and generator companies	Motor and generator companies
AML Sourcing	U.S. recyclers and global oxides sourcing	Collaboration with multinational companies in Japan	Bismuth ingots, Manganese flake
Final processing	Strategic partners (metals and alloys)	None	Confidential collaboration
Other Comments	New sources coming online an available increasingly in coming years	AML has strategic plans for sourcing and separating Samarium ex-China.	AML has several pathways for commercializing MnBi materials and sourcing raw materials ex-China.

AML invites new opportunities for strategic relationships for sourcing oxides, metals, and alloys.

AML "Warp Speed Expansion"

Existing Footprint

10,000 square feet – Alloys and Magnets < 1,000 MTPY

- ✓ Low-rate production, advanced applications prototyping, materials & magnet R&D.
- ✓ Strategic sourcing with suppliers of REOs, alloys, and magnet materials.

Stage II and Stage III

50,000 + square feet – Metals, Alloys, and Magnets - Commercial MTPY

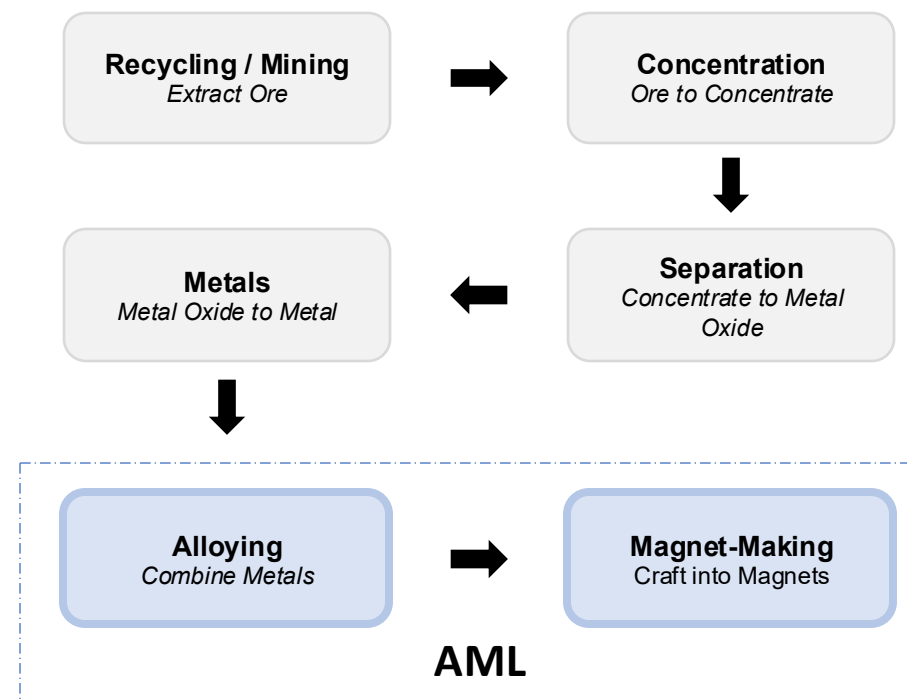
- ✓ Stage II: Scaled magnet manufacturing (proposal to DPA Title III).
- ✓ Stage III: Expansion with metals and alloys production for supporting magnet making.
- ✓ AML may **spin-out new company** for commercial manufacturing and strategic partnerships with REO suppliers and magnet material producers.

Stage IV – AML 10x

Multiple Sites – Co-Location with Suppliers and Customers

- ✓ Global expansion with AML PM-Wire™ manufacturing partnerships with strategic customers and suppliers.
- ✓ AML will be fully integrating material development and scaled in-house compositions for novel magnet materials as well as NdPr.

"Source to Magnet Supply Chain"



AML intends to expand capabilities organically to scale from metals to magnets.

AML - The Future of Magnetics

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

AML-Enabled.com

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"Magneto"
Making Better Magnets
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