

AML - Advanced Magnet Lab

BUILDING A BETTER MAGNET IN AMERICA

**CREATING A NEW & STABLE RARE EARTHS
SUPPLY CHAIN TO REINVENT TECHNOLOGY
& TRANSFORM INDUSTRY**

SEPTEMBER 13, 2019

Building a better magnet

REINVENTING AN INDUSTRY

SUMMARY

Magnets are at the heart of electrically powered machines. As the world evolves away from purely fossil fuel-powered engines, vehicles, and machines, the electric and hybrid-powered machines have to evolve along with it. This need for better, more efficient, more powerful, lighter weight magnets and magnet-powered motors and generators will take over in industries from transportation to wind energy to robotics and more. As a result, demand for the type of magnet that allows this, one made of Rare Earth Elements (Rare Earths), will grow exponentially. Permanent magnets represent the largest group in Rare Earths consumption, close to 25% of Rare Earths used worldwide. Currently, the only practical supply of Rare Earths and permanent magnets manufactured from Rare Earths is through China. This is not a sustainable solution from a country with a history of market manipulation and control along with an economically adversarial relationship with the USA that recently triggered a global crisis. The Advanced Magnet Lab (AML) has developed a novel solution for the optimized design, manufacture and performance of permanent magnets that, combined with efforts from numerous Rare Earth mines worldwide and deep tech Rare Earth processing companies, will streamline the supply chain problem to potentially solve this crisis.

This paper explores the future of magnets and their end-use impact and the solutions to the manufacturing challenges, supply of resources, and creation of a stable, thriving, vertically-integrated “mining to magnet to end-use” industry.

INTRODUCTION

The way the world is powered and propelled is changing. The path is toward fully or hybrid electric transportation, devices, electric machines and other solutions that require electric motors and generators for propulsion and power with optimal performance. At the heart of those motors are magnets.

Self-driving vehicles, flying and hovering vehicles, machines that are cleaner, more efficient and significantly improve the legacy transportation systems of today— these are the machines that will move us into the future. **And the future is now! It is innovation in the field of magnetics that is making it all possible.**

The road to better magnet technology is long and routed through complex territory. It begins in a technological space that hasn't had a major change in more than a century, involving a product that currently requires source materials and natural resources that either come only from China or can only be cost-effectively processed and refined in China at the present time. Not to mention the current conventional wisdom saying that thanks to China's inexpensive labor force and reckless disregard for safety and environmental impact, manufacturing of permanent magnets will only ever only be cost-effectively produced in China.

Even still, thanks to emerging technological innovation and its marveling applications, magnet end-users are eager for real, fundamental, and disruptive solutions within the magnet industry.

Breaking the Bottlenecks

The world is moving toward a new form of propulsion, but there are significant bottlenecks in the supply chain. AML's approach for innovative technologies and its business model solve them all.

Today, the Rare Earth materials from which permanent magnets are made come mostly from China.,Currently the most cost-effective supplier, China produces more than 90% of the world's permanent magnets. The reasons for this are simple, China has a system that cares little for the health and well-being of its workers and even less for the health of the environment. Labor is cheap, and Rare Earths are more easily refined when there is no environmental concern. Also, while cheap labor might lessen the concerns of China for the hazards associated with today's permanent magnet manufacturing processes, it also raises the risk of political upheaval.

E-Mobility

The electrification of transportation

replaces fossil fuel and carbon-emitting powered vehicles with cleaner, more efficient and quieter electrically driven vehicles.

~

However, it should not be at the expense of human rights trade-offs sponsored by China.

Protests in Yulin, China in May 2018 at the Chinese company "Chinalco" ended in a batons and shields attack from Chinese police and arrests of several protesting villagers that complained against working conditions at the Rare Earths facility.

Of course, with little care for workers or environment, the quality and performance of the magnets is about what you would expect. Inconsistent. Far from optimal. And not to the standard required for today's revolutionary machines.

The magnets produced in China are adequate for current uses **ONLY**, because there is no alternative. Latent innovation and new approaches that could significantly improve performance and economics of existing and evolving industries, like e-mobility and clean power generation, are lacking.

In an industry where the driving mentality of good enough is good enough to be successful, the tide is turning to a truth where good enough will never be good enough again. The only way to succeed will be to make not just a better magnet, but a better-designed and applied, optimally manufactured magnet-based end-product. Like a motor.

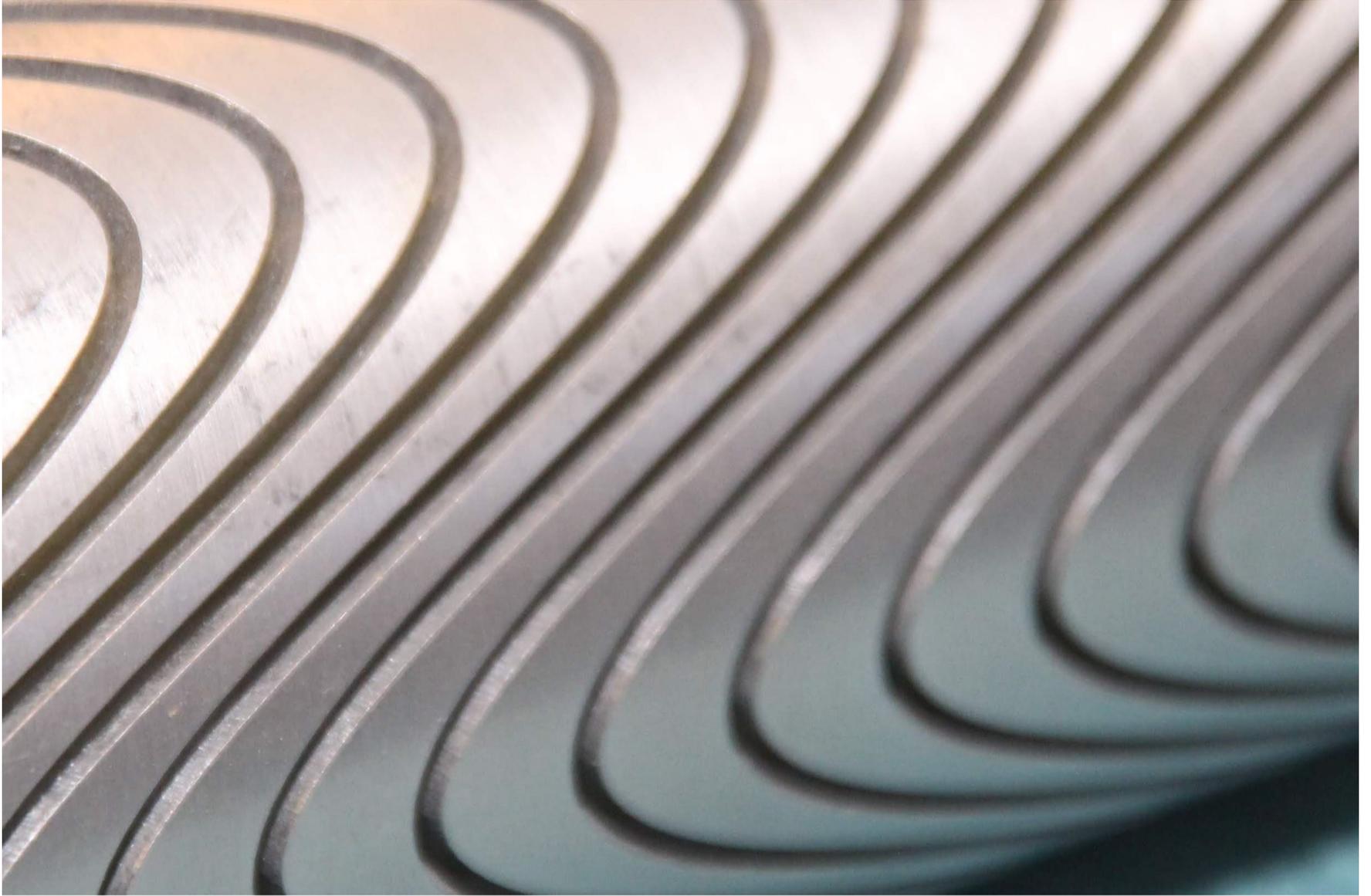


The highest performance commercially available gasoline cars to-date can achieve 0-60 mph in 2.3 seconds, with a top speed of 261 mph (420 kmh). They can also wear a price tag of up to 3 million dollars. Today's \$80,000 electric car, with a motor powered by arguably inefficient magnet design, can already reach 0-60 mph in 3.2 seconds and a top speed of 162 mph (260 kmh). (Source: caranddriver.com, accessed 09/12/2019)

Take Formula 1 cars, for example, which have a World speed record of 231mph. The Formula E (electric engine) has already reached 174mph (75% of fossil fuel engine speed), surpassing the average speed of F1 competition (164mph) and consistently improving its performance. (Source: Bloomberg Nov. 13, 2018)

Innovation is the solution to that better product; innovation in the way magnets are made; innovation in the way the resources for those magnets are mined and refined; innovation in the way the products that use magnets are designed. And what's more, this type of innovation will only serve to inspire the next generation of engineers and designers bent on making a better world.

End-use manufacturers such as automotive companies, aircraft manufacturers, and other users of electric motors (the demand side), recognize the importance of optimum performance and keeping a clear, consistent, predictable supply chain in place.



Optimizing Power Density

THE KEY TO BETTER MAGNETS

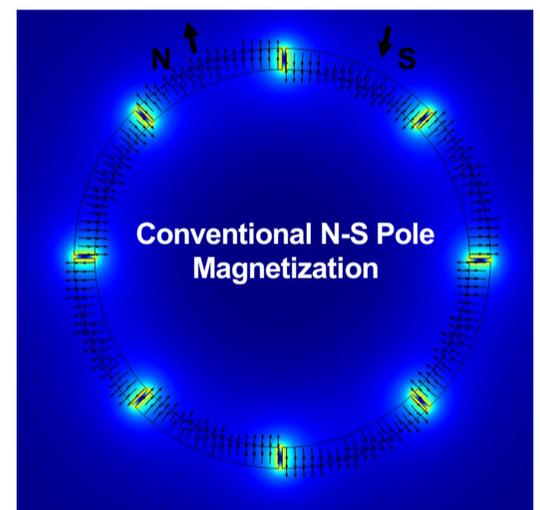
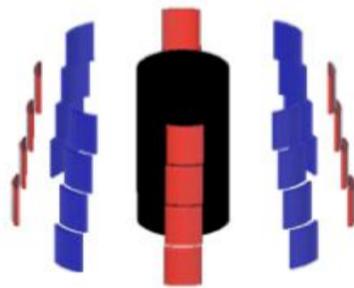
Increasing Power Density, that is, optimizing the ratio of power to weight and cost is the only way to achieve the required performance and price points of the future. Just like for electric vehicles, where battery technology seeks the highest Power Density at the lowest cost, motors using the majority of that energy also need to have the highest Power Density at the lowest cost.

The only way to optimize Power Density in motors—the only way to make a better magnet—is through innovation. The same holds true for the systems generating the electricity to charge the batteries required to support these machines.

For example, Wind Turbines also seek the highest Power Density generators in order to shrink the size and weight of the turbine yielding the lowest levelized cost of energy. The impact is even greater for electrically powered vehicles, where mass drives the power requirements, and consequently, its cost.

These innovations are already in development. Particularly at the juncture of magnet manufacturing for companies that need real solutions for their electrically powered machines and more. The supply chain for Rare Earth materials is the stickiest point, but that, too, is being disrupted by innovation. The inevitable result will be a market expanding away from the controls of China and toward a safer, more responsible, reliable supply chain with higher quality and product design.

Historically and currently, permanent magnets are created as either a batch of piece-part components or substantial chunks of metal, which are then cut and configured into a final physical and magnetic orientation. These individual piece-parts of powerful magnets are assembled through a difficult, dangerous and laborious process for the final end-product, such as a spinning rotor for an electric motor or generator.



The current reality is, product designers dream of having an even more complex assembly, where these magnet piece-parts are arranged in what is called a Halbach array configuration. As compared to a conventional and simple North-South magnetic pole configuration, where a significant portion of the field is unusable without adding heavy iron (shown above), a Halbach array directs most of the magnets' available "energy product" to be fully utilized in the end-product without iron, and therefore yield much higher Power Density. This method, however, is process-intensive, work-intensive, expensive, and more than occasionally physically dangerous to workers.

These complicated Halbach arrays, are cost-prohibitive to manufacture, extremely dangerous and challenging to assemble as piece-parts into the end-product. In a practical way, complicated equals expensive and in manufacturing, expensive, while not always impossible, makes production impractical, unprofitable and therefore not a realistic option as a marketable solution.

The ability to design and manufacture products with significantly greater performance and cost savings is a game-changer. Beyond motors, other products like magnetic levitation systems, magnetic bearings, magnetic gearboxes, and

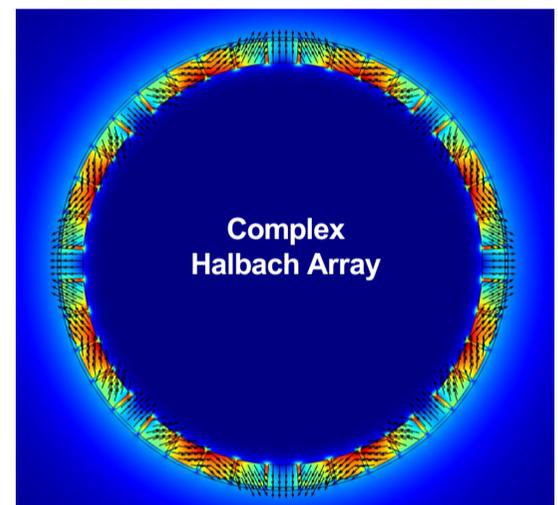
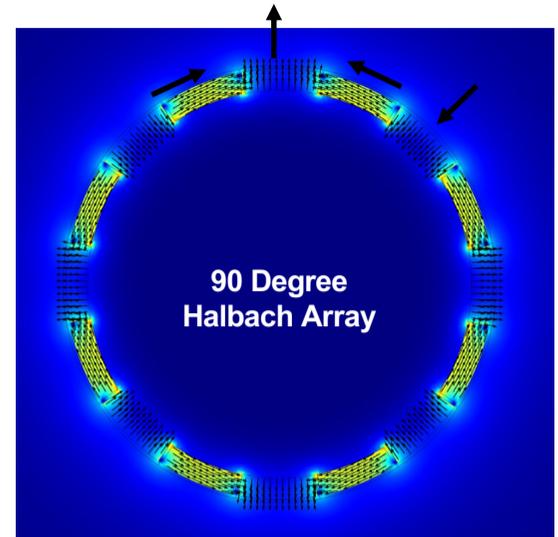
medical devices, would benefit immensely from lower cost and optimized Power Density. And these are only a few examples of many possibilities. AML has developed a novel solution for the optimized design, manufacturing and end-product assembly of permanent magnets.

What is a Halbach Array?

Named for its inventor, Berkeley Labs physicist Klaus Halbach, a Halbach array is a special arrangement of permanent magnets that directs the magnetic field lines so that the field is augmented on one side of the array and canceled to near zero on the other side.

In laymen's terms, such a configuration channels most of the magnetic flux in one direction, forming magnetic poles with a close to perfect sinusoidal distribution. This leads to generation of the maximum magnetic field from the permanent magnet and directs the field in the optimum configuration for the application. In a motor, that provides higher magnetic fields where it counts and removes the need for iron reducing the total weight and size.

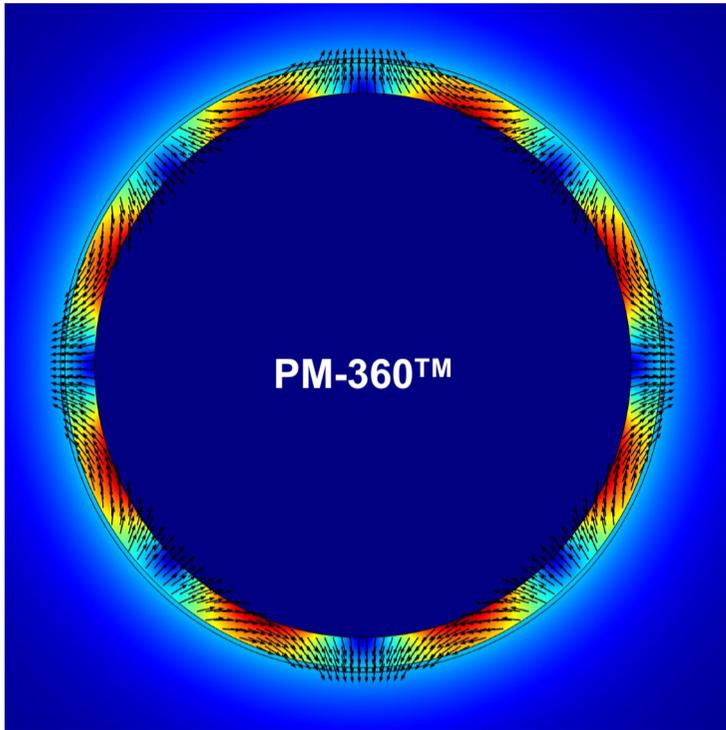
First discovered by John C. Mallinson in 1973 as what he described as a curiosity, the potential was identified and Halbach independently developed his arrays to focus particle accelerator beams in the 1980s.



Called **PM-Wire™**, the technology developed by AML is a uniquely innovative way of manufacturing and configuring permanent magnets. This approach is driven by AML's Technology Platform. A platform which integrates proprietary **MOEM™** electrical machine design software and **CoilCAD™** magnet design software with patented magnet technologies and manufacturing, enabling designers to fully optimize their end-products and applications. Compare that to the way the problem is currently solved—what we call a “me-too” solution—a method using dozens or hundreds of magnet piece-parts to achieve a much less than optimal performance.

And this innovation is just the starting point. For many end-use products like motors, the ideal solution would be a “better than Halbach array” configuration with minimal assembly, lower cost and optimal performance.

AML's **PM-360™** process which optimizes both geometry and magnetic field direction offers unprecedented Power Density, and more, that cannot be matched. Not to mention cost-effectiveness and "better than Halbach array" magnetic fields.



PM-360™ Wins!

Simple, Elegant & Optimized

1. **Higher** Quality
2. **Higher** Yield
3. **Higher** Performance
4. **Easier & Safer** to Use
5. **Lower Cost** to Produce
6. **Lower Cost** End Product

DEFINITION

Deep Tech

A discovery or commercialization of breakthrough deep technology with the potential for world-changing impact and/or a critical milestone in science and technology.

Is AML's solution Deep Tech?

In a word, YES! AML's innovation is a perfect example of Deep Tech. It is tangible and set apart by its profound enabling capabilities, the differentiation it can create, and its potential as a catalyst for change.

AML's Innovation is fundamental, defensible, and distinguished from the existing market; a market built on incremental refinement, that produces a standardized product, and is fragmented.

AML's Innovation includes business model innovation, creating a new and sustainable industry. Not just for magnets, but also to create independence from China for new mining and extraction businesses.

AML's Innovation spans across many diverse applications including energy, transportation, medical and more.



Better Magnets = Better Products

CYCLE OF INNOVATION

In short, innovation that drives an improved magnet product improves the products those magnets go into. That, in turn, creates a cycle of improvement and innovation bound to continue and drive the future of electric machines for more efficient generation and use of energy, which in turn, creates a new cycle of innovation that propels human life into a new stage for our unalienable right of the "pursuit of happiness."

At this point, it is worth noting that no part of this discussion is focused on optimizing petroleum-powered vehicles or machines. It is abundantly clear that the future will be built on higher performing, cleaner running, more energy-efficient

machines that utilize electrical energy. At this moment, all of the biggest and best automakers, aircraft manufacturers and hundreds of start-ups are focused on electric or electric hybrid models. Anyone betting on a purely internal combustion future is, quite simply, missing the boat. Or self-propelled trucking line. Or airplane. Or flying car. Or hyperloop.

The History

Magnets have been at the heart of electric motors and all electric machines since the inception of magnetism in the late 1800s. With the exception of scale and the materials used to make them, the technology of magnetism and making magnets hasn't changed in nearly two centuries.

As we've said, today's most powerful, most effective permanent magnets are mostly manufactured in China, purely due to the fact that China offers the cheapest, quickest source of Rare Earth materials, cheapest labor, and lowest consideration for safety and environmental consequence anywhere in the world.

This single-source model presents obvious opportunity for companies able to tap into the source, but also a very clear and present danger to disruption of a supply chain where one can only get the source materials for a product from one, occasionally economically hostile place.

What if it didn't need to be this way? What if the supply chain for Rare Earths and even the production of permanent magnets could be done in America or other places where safety and environmental responsibility were a more important concern? What if the supply chain had numerous sources that were not dependent on a single source controlled by a dictatorial government?

What if the complete value stream from mining to magnets to end-product could be sustainable?

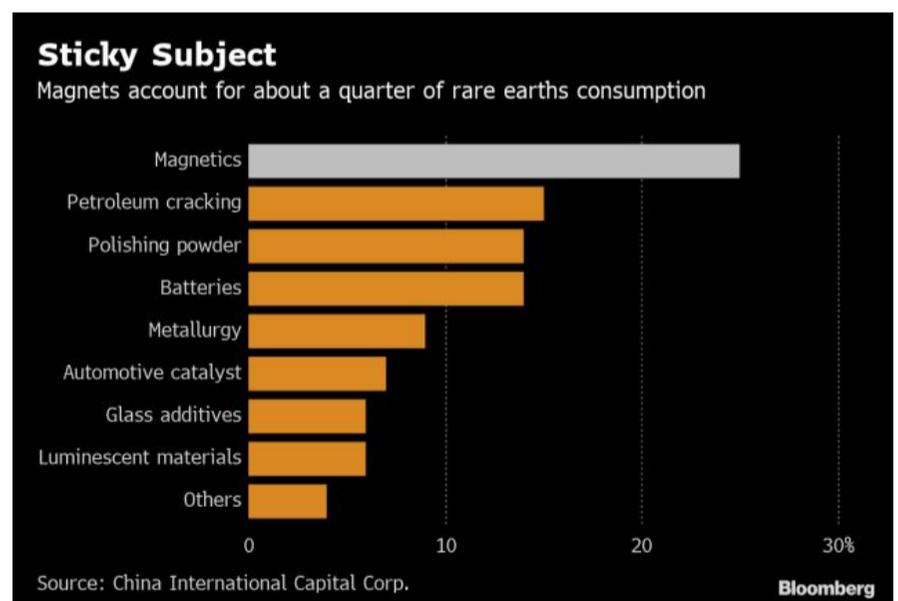
Through the next section, we examine the current state of Rare Earth mining and permanent magnet manufacturing and layer that with new developments in magnet manufacturing to clearly illustrate an industry ripe for disruption. Permanent magnets represent about 25% of current worldwide use of Rare Earths, it is a disruption that is inevitable for the future of electrically powered vehicles, energy production, personal devices, robots, medical solutions and more.

**FROM THE EXPERTS
ABOUT AML**

**U.S. DEPARTMENT OF
ENERGY**

“The proposed technology is a novel process that can compact, shape, sinter and magnetize the permanent magnet material in a highly automated and high-rate process and still provide unique flexibility in terms of shape and continuously changing magnetization direction. The PM-Wire™ process for fabricating a continuous flux Halbach array is particularly innovative.”

- U.S. Department of Energy Technology Reviewer





Rare Earths Are Not Really All That Rare

BUSTING THE MYTH

It's said so often that it's easy to believe the claims. China is the ONLY Source for Rare Earth materials. The only affordable route to get the powerful permanent magnets you need is through China.

The Myth: TRUE or FALSE ?

Rare Earth minerals can only be accessed through rich mining deposits within Chinese borders. Beyond that, separating and extracting those materials from Chinese ore cannot be financially feasible outside of China. Furthermore, because of its low cost of labor, manufacturing of permanent magnets can only be financially feasible in China as well. As a result, Rare Earth permanent magnet technology is dependent on China for its existence and if China decides to weaponize access to Rare Earths, the rest of the world is completely at her beck and call.

ANSWER: Mostly false. Or at least it's not completely true.

Historically, manufacturers were attracted to China for the same reason clothing and toy manufacturers are attracted to China. Cheap labor costs and low consideration for worker safety and environmental considerations. China in the mid 80s declared, “the Middle East has oil, we have Rare Earths.” Three decades later, China controls the practical supply of Rare Earths around the globe.

Rare Earth materials aren’t actually rare at all. They are available in many places around the world. They’re called “rare” because it is so difficult to separate and extract the elemental materials from the mined ore. Also because the ore contains dangerous radioactive elements like uranium and thorium that need to be handled carefully and either disposed of or used safely. This is another reason China is a current source for these metals. The Chinese government has little safety or environmental regulation protecting its workers and citizens from the effects associated with handling Rare Earths. This has resulted in the loss of life, destruction of entire communities, and even the creation of Rare Earth cartels not unlike the notorious drug cartels of South America and Mexico.

And China isn’t the only country trafficking in Rare Earths in these ways. In fact, Australian mines have been sending their “dirt” or ore to both China and Malaysia in an attempt to realize the same benefit without being held captive to China’s economic whims. In other words, Australia is shipping its “pollution” to Malaysia. This kind of action just creates another threat of destabilization in the market.

In 2012, about 3,000 Malaysians staged a protest against a Rare Earth refinery being built by Australian mining company Lynas over fears of radioactive contamination concerned it posed health and environmental risks.

In 1992, a Malaysian refinery operated by Mitsubishi of Japan, was closed after protesters claimed it caused birth defects and leukemia.

(Photo - EPA pic, August 23, 2018)



There are alternatives

Rich deposits of Neodymium and Praseodymium, necessary Rare Earth materials for permanent magnets, do exist in other areas of the world. Locations like the Mountain Pass mine in California, Round Top mine in Texas, and Bear Lodge mine in Wyoming, have the added benefit of minimal radioactive elements within the ore. Add to that its stateside location in a politically stable part of the world and it is a tremendously attractive resource for the materials so in demand for magnet manufacture. Along with companies like AML, developing magnet manufacturing technology and processes (**PM-Wire™** and **PM-360™**), cost-effective manufacturing solutions on American soil can be opened up, and suddenly, the market is poised to change dramatically.

The difficulty with the ore from Mountain Pass and other mines like it comes in the separation and extraction process. To date, refining the ore from these mines is so expensive and site-specific that the only cost-effective way of doing it has been to ship the “dirt” to China for extraction. With ore from other parts of the world; Australia, Canada, and others; the dangerous elements are left for China or Malaysia to deal with. Once the Rare Earths are extracted for use, a mining company’s only option is to ship it to China to be made into magnets. This is the current case for Mountain Pass, the only U.S. Rare Earth mine in operation at this time.

Brazil is also an alternative latent partner-supplier of rare earths. It has half of China’s rare earths reserves and is the single largest niobium ore global producer with more than 90% of global market share. In this case, Rare Earths are actually a by-product of niobium mining production.

Commodity or product?

Rare Earth magnets have been seen from only one side since their inception. Because they are made from mined materials and only a limited amount is available at any given time, they are often seen and understood as commodities. For example, the magnet industry defines magnets as a function of their weight; the amount of raw materials used to manufacture them. A better approach is to recognize the magnets within the end-use product, such as a motor. Because of the inherent reliance on availability of Rare Earth magnets required for the products we use on a daily basis, they should be treated more as an end-use product; for example, the magnet rotor in a motor.

Numerous Rare Earth mines around the globe have been investing significant sums in developing their own separation and extraction processes. Since each lode of ore requires its own specific process, dictated by the elements included in the ore itself, every mine requires its own unique process for extraction.

The demand for Rare Earths today is large and growing steadily. The explosion of new electrically driven products, both military and commercial is poised for a market breakout as production and manufacturing increases over the next decade. Without Rare Earth resources, economies could decline and countries would be unable to produce essential end-products required for national security. **In most cases there are no alternatives.**

The threat has become existential

Combined with the possibility growing over recent years of China “weaponizing” the Rare Earths market; that is, controlling the price and supply and flow of Rare Earth materials to its benefit; it has become a necessity for mines in other countries to develop their own processes and maintain a stable supply chain.

End-use manufacturers such as automotive companies, aircraft manufacturers, and other users of electric motors (the demand side), recognize the importance of optimum performance and keeping a clear, consistent, predictable supply chain in place.

The present technology developments at AML have generated a strong pull from industry participants for **PM-Wire™** and **PM-360™**. Companies ranging from start-ups to fortune 100 and Global 2000 are engaged with AML as part of their new product developments. Products like propulsion motors for drones, flying cars, aircraft, electrical vehicles, and consumer power tools.

RECYCLING FOR RARE EARTHS

Mining existing stores

While the process of mining Rare Earth materials and refining the valuable materials out of the ore from such efforts is the only current process capable of producing these elements at the volume required for industrial use, it is not the only way of skinning the magnetic cat.

Urban Mining Company offers another way in to the Rare Earth minerals required for the production of permanent magnets that doesn't necessitate shipping ore to China to be extracted and produced into permanent magnets.

The Austin-based company commercialized a process for recycling magnets using a patented Magnet-to-Magnet™ process designed to produce recycled neodymium-iron-boron (NdFeB) type magnets.

Recovered "waste" from devices like motors, cell phones, computers, tablets, televisions and more, can be repurposed into new magnets and magnetic devices without relying on a new Rare Earth supply currently only available in a practical way from China.

Because the elements used in the materials being recycled have already been refined, the safety and environmental concerns are limited as the recovered NdFeB is reused into new magnets.

Clearly, the recycled materials are not available in quantities sufficient to meet the supply chain needs of a new and growing industry or large-scale commercial production, but availability through recycling does offer another way of thinking about the issue and another, safer, cleaner way of solving the challenge.

How big of a deal is it?

At the end of July 2019, the White House invoked the Defense Production Act of 1950, a Presidential Determination, for the **domestic supply of Rare Earth materials** and the **production capability for Permanent Magnets** as **ESSENTIAL TO NATIONAL DEFENSE**.

The Defense Production Act is a federal law put in place and headed up by the Truman Administration at the start of the Korean War. The act has been reauthorized some 50 times since then and was designed as a part of a broad civil defense and war mobilization effort at the time in response to the nation's Cold War posture.

Addressing the threat on U.S. National Security is a focus for AML and the current domestic Rare Earth mines. Together, this will result in production of a steady supply of new, higher quality, lower cost permanent magnets to power the motors required for military aircraft, ships, submarines, and meeting the coming demand for e-mobility solutions from electric cars, trucks, trains and even scooters, aerospace, commercial flight, electric turbines, medical solutions, and more.

Everybody wins with a vertically-integrated solution.

Miners, magnet producers, magnet users and the end-use consumer. With a higher value magnet and end-product, these stakeholders are less impacted by China's Rare Earth subsidies which result in unstable commodity pricing.

AML is working together with international mines, industry consultants, and experts in order to streamline the entire value chain from mine-to-magnet-to-end-product. The effort is to form partnerships involving relevant supply-and-demand players prepared to compete with China's market dominance.

As in any business strategy that depends on natural resources, vertical integration is the right answer to the competitiveness question.

The actual scenario is leaning towards coalitions, such as the Pan-American coalition that extends from Canada to Brazil to Chile and has the potential to offset China's grip over "The Americas."

National Security Cornerstone

RARE EARTHS

The U.S. Military is an important buyer of Rare Earths and products using Rare Earths. Permanent magnets are required for navigation, weaponry and electric propulsion motors for a new generation of vehicles, aircraft, ships and submarines.

The U.S. Navy's newest warship, USS Zumwalt (DDG 1000) is the largest and most technologically advanced surface combatant in the world. Zumwalt is the lead ship of a class of next-generation multi-mission destroyers designed to strengthen naval power from the sea.

The Zumwalt features all-electric propulsion. The electric drive eliminates the need for drive shaft gearing, reduces acoustic signature, and produces an increase in available power for weapon systems while improving the quality of life for the crew.

The significance of such an endeavor is not only felt in the economics of the situation but also emerges in the social, human values of freedom enshrined in the American way of life. It is intertwined with other geopolitical issues of global power like the telecommunications debate over 5G technology.

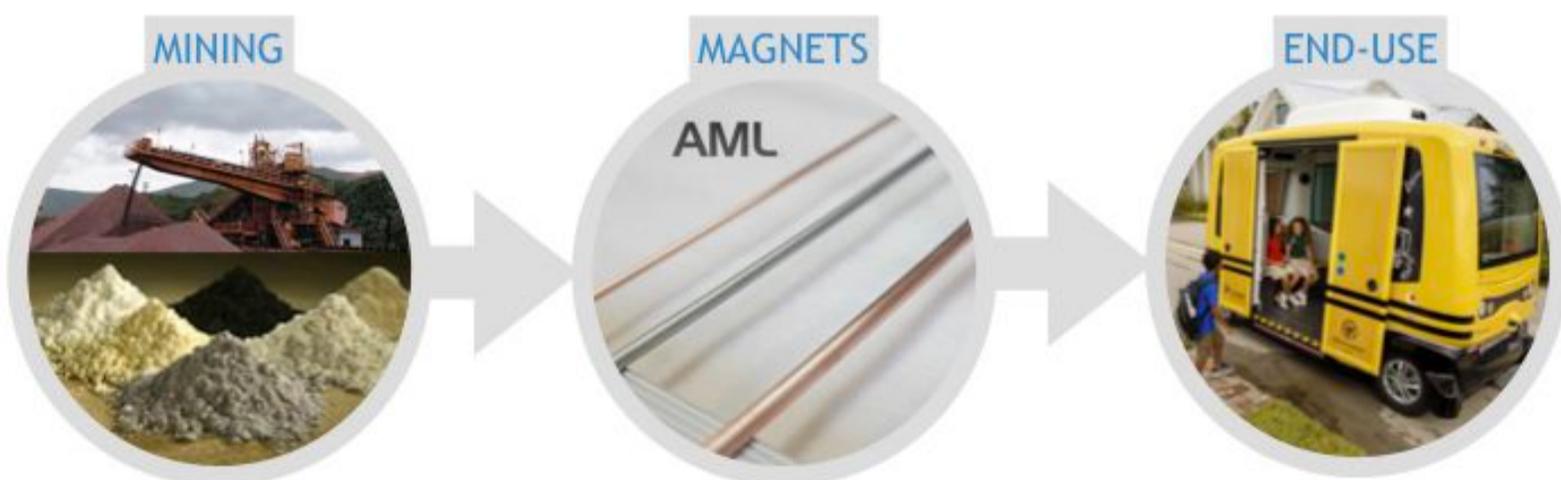
As a result, this endeavor requires support from all federal governments of the participating nations.

China and Russia have been working together toward a common agenda for a social-communist lifestyle since 1991. This effort was amalgamated by a cultural-economic treaty signed in 2001 during the BRIC Summit between Russia's Vladimir Putin and China's Xi Jin Ping with support of former Brazillian social-communist president Luis Inacio Lula da Silva (currently under arrest for corruption).

So, it can be inferred that we are not living in a simple "trade war" with China but in a "social-tech war" with global implications spurred by availability and access to natural resources and innovation. Thus, joining forces among natural resources-rich countries and American deep tech companies is crucial to a successful prevalence of freedom and justice in the near future for the whole of the Western World.

The result is related to sovereignty, human values, and way of life. Therefore, **building a better magnet in America** is essential to our country, our citizens and our allies, too.

The fact that the U.S. Government acknowledges the importance of a clean, supportable, undisrupted domestic supply chain for permanent magnet production just serves to illustrate the way the industry tide **MUST** turn. It **WILL** be a major part of the world economy going forward. As it has at every major technological juncture in its history, the U.S. needs to **LEAD THE WAY.**





What makes magnets important?

MAKING THINGS POSSIBLE

Without permanent magnets, much of today's most advanced technology, or at least the technology that makes life more interesting, profitable, and technologically advanced, would not be possible.

Set aside what's being developed. Many of the devices we carry and work with every day today would not exist without permanent magnets made from Rare Earth materials.

Smart phones. Laptop computers. Speakers and microphones. Drones. Studio and cinema lighting and projection. Heavy industrial uses. Hybrid vehicles. In fact, all transportation—land, air and sea—are going electric or hybrid electric including new modes of transportation such as eVTOLs. Affectionately known as “flying cars,” these Jetsons-like electric vertical

take-off and landing vehicles will be flying the sky's in less than 5-years for Urban Air Mobility, organ delivery, and emergency services.

Powerful permanent magnets are the beating heart of all of these things. Without access to Rare Earth materials, the permanent magnets that make these things possible, wouldn't be possible either.

AML's comprehensive technology platform enables the efficient production of a new generation of permanent magnets that delivers 10-50%, or even higher, performance increase across a broad variety of end-products and applications. More powerful. More efficient. Less expensive. And significantly safer to produce and use.

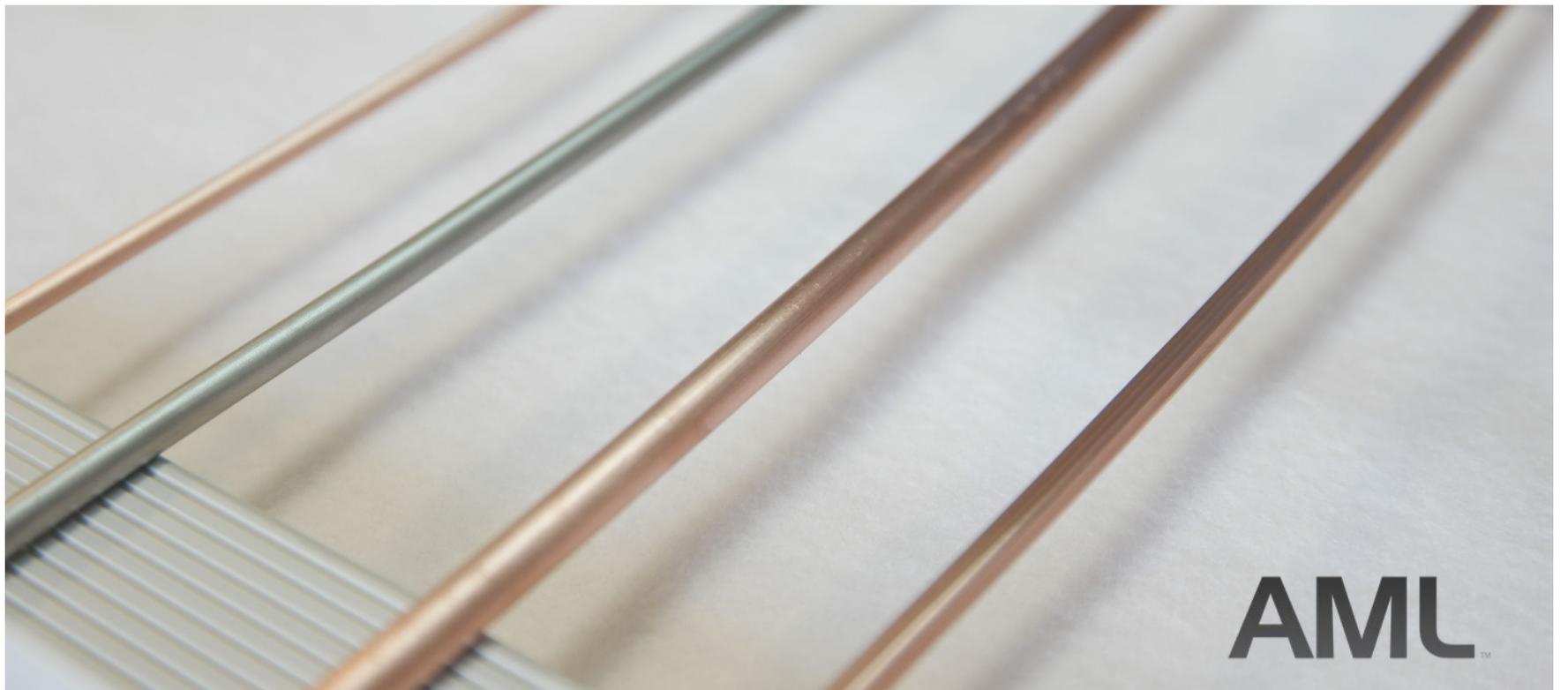
The Old Method of producing permanent magnets, the one that is dependent on China and Chinese labor, produces small piece-parts or often large magnet blocks that need to be cut and placed together into arrays to generate the kind of power required to run electric machines and other magnetic systems.

That process is manual, dangerous for workers, and produces magnets that exhibit low yield, poor quality, inconsistency and are restrained from optimizing end-product performance and capabilities. While some companies outside of China are replacing humans with robots to automate the process, the product is still the same and costs are not competitive. Furthermore, in both cases, the end-product design is constrained to designs made from limited sizes and shapes. It is a "me-too" product designed for a highly fragmented market.

The New Method, AML's novel approach, powered by the innovations of proprietary software and its **PM-Wire™** and **PM-360™** processes will enable safe, streamlined magnet manufacturing, along with unique solutions that will result in more powerful, more efficient, less costly and lighter end-products. It is an entirely new way of thinking about magnets and delivering performance to products powered by magnets.

This New Method does not require the manual element that made China the de facto leader in the industry. **PM-Wire™** and **PM-360™** are not piece-part magnets. They are a fully optimized solution for the end-product. **A solution that does not compete in the fragmented "me-too" market. A solution that is less sensitive to China's Rare Earth commodity price and market manipulation.**

This is an enabling technological solution that brings sustainability to the entire industry. And it is "source agnostic," meaning the Rare Earth materials used can come from the U.S., Australia, Brazil, Canada, Greenland, Africa, China, Vietnam, or even Afghanistan. For the U.S., a supply of domestic Rare Earth materials allows the entire process to become a domestic industry empowering new thinking across a vast array of industries around the world. **It is a complete transformation in the way magnets are produced and used, at the same time, reigniting the American manufacturing sector.** For the Americas, it may ignite a new Occidental coalition of freedom and prosperity as together we become stronger and less dependent on the Orient.



Our Conclusion

WHAT COMES NEXT?

The way we all move around in the world is changing. The engines that built America over the last century and more will be giving way to a new generation of propulsion, power, and energy requiring different materials, a new way of generating movement, and an innovative approach to solving these challenges. **It is an approach with magnet technology at the center of the motors that move us.** And the change is coming quicker than most people can envision.

Electrically powered machines with magnets at their hearts will be replacing virtually every existing type of fossil-fuel powered machine in industries around the globe. And when they do, there needs to be a solution to the Rare Earth materials required to produce magnets outside of China; outside of the traditional commodity market for these resources.

The reasons driving this change are varied and wide ranging; from practical, hard economic, market-driven inevitability; to environmental impact; to responsibilities to the health and safety of the American workforce. These reasons are making it clear that the need for magnets having higher quality, higher performance, easier and safer to use, produced at a lower cost, yield a lower cost, and optimal performance of the end-use product will grow exponentially over a predictably short time horizon.

But in a market where most of the materials required to manufacture the magnets needed to make these machines possible come from only one source, there is an obvious need for an innovative solution to where those materials come from and how those magnetic components are manufactured.

AML has already solved several of the most challenging magnet manufacturing challenges with its own novel approach that is shifting the paradigm and is poised to create what amounts to a new market in magnetics.

This is not incremental improvement. It is transformational. AML is leading a truly revolutionary change taking us from a fragmented, "me-too" market to a streamlined, vertically-integrated market delivering better magnets and enabling better end-use products.

The company is currently leading the charge into the next steps that will lead to a resurgence of the American manufacturing sector in magnetics. Rare Earth mines across the U.S. and around the world are working diligently to solve and streamline the supply chain challenges.

It is true that China is the only practical provider of Rare Earth elements and manufactured permanent magnets in the world at this time. But that time is changing. And changing swiftly. Toward the inevitable creation of a stable, thriving, vertically-integrated "mining to magnet to end-use" industry that will supply a beating heart to the machines of the future.

~ end ~

POISED FOR EXPONENTIAL GROWTH

Disrupting traditional industrial processes

Best-selling author and serial entrepreneur Peter Diamandis talks about his 6-Ds of exponential growth.

"The Six Ds are a chain reaction of technological progression, a road map of rapid development that always leads to enormous upheaval and opportunity."

DIGITIZATION - Does the business utilize or rely on digital technology over manual labor?

DECEPTIVE - Is the business uniquely deceptive because of a unique approach?

DISRUPTIVE - Does it have the potential for massive and disruptive growth?

DEMATERIALIZED - Does it alleviate or significantly change the use of materials?

DEMONETIZE - Does it remove or significantly reduce the cost?

DEMOCRATIZE - Does it make the technology more available for everyone on the planet?

AML's PM-Wire™ and PM-360™

Checks all six D's

Everything AML does is anchored in proprietary software processes, **DIGITIZATION**, exploring the optimal approach to solve a challenge.

The name alone makes it seem **DECEPTIVE**. PM refers to permanent magnets, and PM-Wire™ is a completely new solution to an old technology.

AML is doing PMs in a totally revolutionary way, **DISRUPTIVE** to the current Chinese stronghold.

On **DEMATERIALIZED**, it breaks the single source model. It reduces the part count of the final end-product sometimes from 100s to a single part.

It **DEMONETIZES** by removing today's "me-too" magnets with a unique and optimized solution.

And what could be more **DEMOCRATIC** than making better magnets more effective, more affordable and easier to use in a wider variety of products?

CONTACT US

COMPANY

AML is a recognized leader in the development of technologies and solutions for electrical machines and other magnet-based applications.

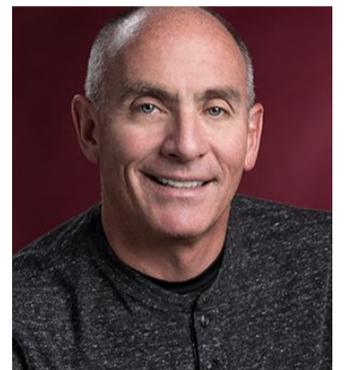
AML's capabilities are driven by a Technology Platform comprised of a comprehensive portfolio of intellectual property and know-how. This includes proprietary software for the optimization of electrical machines and magnet solutions, magnet and manufacturing technologies.

As a result, AML is a world leader at optimizing magnet-based applications that address products and solutions for energy, transportation, medical, and research.

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Co-Founder, CEO and Chairman
AML - Advanced Magnetics Lab

More than 30 years of experience at the forefront of innovation and technology solutions including superconducting magnetics and supercomputers, robotics, manufacturing and sustainability. Teamed with world-class scientists and engineers, Mark leads the company's strategic direction including developing technology and product solutions, business strategies, intellectual property strategies, and strategic partnerships.



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Disclaimer - The information contained in this white paper is for general information purposes only. It describes the general nature of the Rare Earth and Permanent magnet industry, the current crisis and the potential solution for a new and sustainable solution. It is the opinion and vision of the Author and the Advanced Magnet Lab, Inc. (Company).

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Reimagining the Magnet Technology that Drives the World