



COMMERCIALIZATION ASSISTANCE PROGRAM

DOUBLE-HELIX™ (DH) ELECTROMAGNET TECHNOLOGY

Business Opportunity:

There are applications where precise and strong magnetic fields are desirable but currently very expensive to generate if attainable at all, such as in high-speed, high-power generators. The major constraints on the generation of high-quality, high-strength magnetic fields are: 1) the creation of near perfect fields, currently unattainable without complex manufacturing and ongoing maintenance; 2) the fabrication of physical structures to hold the coils, reliable under very large magnetic forces; 3) the generation of high field strengths requiring large currents without heavy windings, support structures, and cooling systems.

Advanced Magnet Lab (AML) has developed several concurrent technologies that enable the design and production of high-field quality, high-field strength, reliable, and low-weight electromagnets. These integrated technologies are: the Double-Helix™ (DH) winding, CoilCAD® design software, and automated manufacturing techniques. The cumulative addressable market for applications, like field generation for medical devices (proton beam treatments) or high-speed motors & generators stators, is estimated to be billions of dollars.

For material, medical, and particle beam markets, AML is looking for strategic partners to complete product or production designs leveraging AML's technologies. For military applications of high-power motors and generators, AML is interested in a joint product development program with prime contractors. For all other industrial areas, AML is looking for application-specific licensees.

Company Background:

AML is an engineering and development company focused on electromagnetic technology. The company was founded in 1995 and has a staff of 12 full-time employees. A specialized lab in electromagnetic analysis has generated proprietary design software and a portfolio of patents on coil designs and manufacturing techniques. AML has enhanced research, design and manufacturing capabilities with an in-house superconductivity lab. On-site prototyping and low volume production facilities permit translation of discoveries into tangible outputs for evaluation.

Industry Problem:

Currently, products/applications which use electromagnets are limited to mid 19th century technology based on 2D solenoid, saddle or racetrack coils. For high field strength (high current) applications these conventional coil types require physically bulky support

structures, achieving only modest reliabilities and for resistive applications require complex cooling systems. In addition, even with complex geometries and corresponding complex manufacturing, these coils do not achieve high field uniformity over significant volumes. New coil designs, design methods and manufacturing techniques are needed that address the constraints on generating high-quality, high-strength magnetic fields.

Technology:

AML's technology consists of the Double Helix concept, the CoilCAD design software and the innovative manufacturing techniques, which enable AML to develop products from concept to delivery or licensees to create optimized coils for end-use applications. AML's Double-Helix is a modulated-solenoidal winding which can produce complex transverse magnetic fields without errors, in either superconducting or resistive applications. Conceptual designs are optimized using the company's CoilCAD software. The final designs are then converted into standard CNC machining code which drives an automated manufacturing process. AML has developed proprietary coil-in-groove manufacturing techniques as well as processes for the creation of coils directly from conductive-surfaces for the manufacturing and stabilization of splice-less coil windings.

Advantages and Differentiating Features:

Differentiation features include:

- Double-Helix™ winding design produces magnetic fields free of errors
- CoilCAD® seamlessly integrates computer aided design and computer aided manufacturing
- Highly automated direct manufacturing of coils and coil support structures, with little or no integration or disparate parts, reducing manufacturing complexity
- Splice free stabilized windings of nearly unlimited length improving mechanical stability and reliability

Stage of Development:

AML's technologies have been validated through the full design, optimization and manufacturing cycle for low-volume electromagnetic coil products for applications such as scientific-research projects, electron-beam steering and a prototype proton-therapy medical device. In addition, proof-of-principle coils have been produced for many other applications including electromagnetic propulsion.

Competing Technologies:

Design of coils and windings is a common engineering skill and can be found in many companies. However designs are based on conventional windings. To achieve high-field density, high-field and good reliability requires iterative design & testing and complex manufacturing & calibration. These expensive design and manufacturing techniques are unnecessary using AML technologies.

Applications:

The applications for AML's technologies are found where extremely high-quality magnetic fields and low weight are required. Examples include:

- ***Electric rotating motors or generators:*** High-power, high-speed, low-weight rotating machines, such as airplane mounted generators, require high-power density to be practical and precise magnetic fields to prevent field/rotation coupling from destroying the device.
- ***Medical applications:*** MRI and proton beam treatments need high-precision strong magnetic fields precisely controlled, but current technologies require expensive calibrations and physically large devices.
- ***Propulsion applications:*** Kinetic weapons, alternative satellite launchers, or all-electric airborne or marine vehicles need very high power and low-weight to be practically deployed.

Benefits:

Double-Helix™ (DH) is a fundamental technology providing new levels of capability, performance, and reliability - enabling new magnet application and product solutions.

Design benefits

- *Optimized fields* – quality, strength
- *Optimized geometries* – Coils are scalable in size, unlimited length, with variable aperture, curved, twisted, straight, flared or any combination of these functions
- *Improved cooling* – Coil created directly from conductive surfaces enable improved heat distribution and cooling
- *Rapid design and product development* – Highly automated and integrated manufacturing shortens time to market by removing the need to develop tooling.
- *More compact, lower weight and more efficient* - Large power densities enable smaller and lighter designs by 50% or more for the same or increased efficiency
- *More reliability* – Tight automated manufacturing tolerances, repeatability, and design stability to large forces produce inherently more reliable parts

Manufacturing benefits

- *Quality and Reliability* – With automated consistent manufacturing process
- *Simple manufacturing* – No tooling or complicated inserts

End-use benefits

- *Reduced space requirements* – Applications that used to require huge volumes such as MRI machines can now be housed in smaller rooms.
- *Newly enable applications* – Applications such as airplane mounted generators and electromagnetic propulsion systems can now be considered as highly efficient high-speed generators can now be available in a small, light format.

Intellectual Property:

Double-Helix™ (DH) is one of several electromagnetic technologies developed by AML. AML has existing U.S. patents and numerous patent applications, which cover the coil technology, design software, manufacturing processes and product applications.