# BEYOND THE HYPE:
## UNDERSTANDING AI AND THE OPPORTUNITIES

Stephen Amsterdam

**Portfolio Manager & Senior Research Analyst**

With assistance from the Emerald Technology / Investment teams

Derek Fisher
**Director of Technology Research**

Nathan Jones, PhD, MBA
**Research Analyst**

EMERALD
DRIVEN BY RESEARCH
SINCE 1992

# Innovation Starts Small...

*One of the most prevalent investor discussions so far in 2023 has been the recognition of the potential benefits – and risks - of Artificial Intelligence (AI).*

The topic has, unsurprisingly, created debate regarding where the potential for investment lies and whether the winners have already been decided. In this paper, we briefly articulate Emerald's position on the topic of AI and discuss areas of opportunity across the entirety of the capital spectrum.

- Many investors mistakenly believe AI will be dominated by Large-and-Mega-Cap Companies. Emerald believes that while this is true in some segments, small-and-mid-cap companies will see substantial opportunities as well.

- To understand the landscape, investors must first realize what AI is, and isn't.

- The emergence of AI will create a need for a new ecosystem to support its growth – across hardware, software, systems, and infrastructure.

- The application of AI for productivity enhancement will have broad-reaching implications across a myriad of industries and will potentially cause meaningful market share shifts among incumbents.

- Emerald believes that only through proven, fundamental, bottom-up research can investors successfully navigate the rapidly changing investment landscape of AI for both identifying the beneficiaries as well as avoiding the endangered.

### *Artificial Intelligence – Beyond Large- and Mega- Cap*

Investment opportunities within artificial intelligence (AI) have become a major topic of discussion throughout the investment community and society at large. Clearly, there will be significant amounts of capital invested, created, and squandered as the AI investment cycle evolves. Many investors believe that due to the enormous computing power required to create AI systems, investment opportunities in AI are limited to 1) venture-backed "unicorns" (inaccessible to most investors) and 2) large-or-mega-cap public companies. Throughout Emerald's 30+ year history, we have steadfastly believed small-cap equities are a worthy investment vehicle for leveraging emerging secular trends – something which many investors mistakenly ignore. We contend AI is no different.

To unpack the reasoning behind this assertion, it is important to: understand what AI is (and isn't); know how it differs from traditional software; break down the elements of an AI system; and look at how those systems are implemented.

### *AI – WHAT IS IT?*

In broad terms, AI systems are another evolutionary step in programming. Traditional software is highly structured such that every input, action, computation, and process is mapped and codified by rules written into the program. This necessitates potentially millions of lines of code and very precise instructions for even relatively simple operations. AI, by contrast, uses comparatively few instructions and algorithms which "learn" through exposure to vast amounts of data. We will not attempt to delve into the philosophical debate and ramifications of true artificial intelligence vs simulated intelligence, and while we believe ethical considerations for a technology as powerful as AI are highly relevant, we assert the breathtaking current capabilities of AI represent highly sophisticated, simulated intelligence and not true sentient intelligence.

AI systems can largely be grouped into variations of two main types: 1) a specialized, application-specific model that enables a method to solve a particular problem or 2) a "large language model (LLM)" that utilizes a massive database of text to broadly approximate general intelligence. The creators of either type of model amass a database of information (images, documents, experimental results, etc.) that are believed to be at least somewhat relevant to the model's stated goal. That data is then fed into a series of algorithms which identify and gauge correlations between millions/billions of variables. The model is then exposed to new data, and the model's output is evaluated, creating a feedback loop that further enhances the model. This process is generally referred to as "Training." Introducing new information to an AI model is known as "Inferencing" and the cycle of training/inferencing is repeated continuously while the model continues to evolve, learning from each new interaction. As the point cloud becomes more

complex, the answers give the appearance of becoming more "intelligent," but in the absence of a good correlation within the model, systems still provide an output that oftentimes bears no relevance to the input query and are known as "hallucinations."

At the heart of any AI system is a processing core; these are highly specialized processors capable of handling billions of variables to produce astonishingly precise outputs that create the appearance of "intelligence." These processors are unique in a number of ways – they are immensely complex and built at the most demanding processing nodes with transistor counts measuring in the hundreds of billions per server; they are remarkably power hungry, using 3X-5X the amount of power versus a traditional datacenter server (with roadmaps articulating as much as 10X); they are interconnected with other AI servers at breathtakingly high data rates, requiring an evolution in communication speeds; and they utilize memory in unique ways, requiring more immediate memory access than traditional systems.

## OPPORTUNITIES FOR TODAY AND TOMORROW

We are not going to attempt to speculate on the greatly debated societal implications of AI running amok or the risk of causing an "extinction-level" cataclysm, but we acknowledge that AI stands to impact almost every aspect of our world. Most people don't realize they already interact with multiple forms of AI on a near-daily basis. For example, Siri, Google, Bing, Meta, YouTube, Spotify, TikTok, and other popular sites/apps utilize some form of AI for their recommendation engines to maximize users' engagement, thereby maximizing advertising revenue and consumer spend. In addition, companies use AI to create imagery for advertising, students utilize AI for "help" with homework and tests, lawyers implement AI for drafting basic documents, and it is estimated that over 75% of programmers currently use AI tools with >30% of newly written code suggested by AI (many contend a good deal of those suggestions do not work, but the trend is undeniable).

Discussions regarding unmanned systems used for military and defense applications are ongoing, and while none have been officially fielded by the US Department of Defense, there are numerous experimental systems that are able to exercise some form of autonomy in a combat situation. Given the cost of manned systems, the sophistication of peer adversaries, and the desire to protect the warfighter, it is almost a foregone conclusion that AI in the battlespace will become a reality over time.

Emerald's life-sciences analysts posit there is the potential for machine learning and/or AI bio-simulation to help drug development by accelerating the process of active molecule discovery, finding potential new applications or combinations of existing drugs, and simulation of some preclinical and toxicological studies. All three of these approaches have been aided by

computational efforts in the past, and AI should accelerate that progress. We would point out that the Food and Drug Administration (FDA) will likely be very slow to adopt AI-driven approaches by virtue of the fact that it is an organization focused on patient safety.  Even so, we believe investment opportunities will emerge over time.

As an active growth manager, Emerald is keenly focused on transformational technologies that can disrupt the status quo in a particular industry.  Machine learning/AI represents a technology capable of disrupting the status quo for multiple industries. There is no debate that AI and the applications it enhances are secular growth markets for the foreseeable future.  Historically, these are the types of moments where small, disruptive, pure-play technology companies can become market share leaders and displace larger incumbents.

## OPPORTUNITIES LIE BEYOND LARGE-AND-MEGA-CAPS

Today, when investors talk about AI, most are focused on either the companies building large language models attempting to recreate general intelligence, or companies focused on designing the processors themselves.  We concur that the capital required to create and run these large language models, as well as the semiconductor chips necessary to perform the calculations, is such that most smaller capitalization companies will not be able to become leaders in those specific segments.  However, we strongly contend that while these models/processors are critically important to the overall success of AI, those segments will not be the only investable trends as the AI market evolves; indeed, opportunities exist across the entire market cap spectrum. As a general reminder, the capital spending (Capex) and cost-of-goods-sold (CoGS) of large- and mega- cap companies represents revenue for mid- and small-cap firms.

AI-focused workloads are causing a fundamental re-architecting of the datacenter in its entirety. This change is the result of multiple factors – all of which create opportunities within smaller, often pure-play companies.  While by no means a comprehensive list, below we highlight some potential examples of system(s), hardware, and infrastructure investments advantaged by the growth of AI:

- The chips required for AI are some of the most complex designs ever imagined and require the most advanced manufacturing methods, as well as a significantly increased reliance on complex packaging technologies.  The emergence of generative AI has accelerated advanced packaging adoption and newer heterogeneous packaging technologies.  Thus, while semiconductor packaging and test has historically been a highly cyclical industry, AI may add a secular growth driver that could amplify a cyclical recovery in 2024 after 2023's pronounced contraction.
- An AI server is a specialized piece of equipment.  Many of the larger AI companies require highly customized server designs for their AI systems.  This creates an opportunity for

contract manufacturers with requisite hardware engineering skills to gain significant market share.  For many large AI companies, supply chain relationships, and flexibility to rapidly design, customize, optimize, and produce AI systems is of paramount importance during this early stage of the market.

- The power requirements of an AI server are multiple times greater than a typical server due to the immense computational load.  Power is becoming THE fundamental requirement of a datacenter, and the availability of power is the gating factor of datacenter growth.  Requirements for power per rack are increasing dramatically, but space allocated per rack is largely unchanged.  The heat generated by AI servers causes multiple issues and thus cooling becomes a more meaningful problem as density and heat increase.  In response, power supplies are being redesigned to utilize more efficient compound semiconductors that can deliver more power and generate less heat while cooling technology is evolving to better handle operating temperature limitations.

- Datacenter operators are faced with demand that is forecast to meaningfully outstrip current capacity due to the proliferation of AI applications and the additional power requirements.  McKinsey estimated that in the US alone, 35GW of total datacenter capacity will be needed in 2030 versus just 17GW in place in 2022.   Whether this goal is achievable is subject to debate, but the demand for datacenter power is undeniable, which is leading to a potential investment cycle in datacenter operators that desire to build AI-optimized datacenters with power, cooling, and reliability requirements specific to batch-AI workloads (as opposed to mission critical, low latency workloads).

- Beyond power and cooling, the infrastructure of a datacenter is evolving to accommodate the higher bandwidth requirements of machine learning and AI.  Optical technology is transitioning to higher speeds and potentially coherent light to better manage bandwidth requirements.  Debate continues regarding a transition from direct-attach copper cables to either active copper or optical, which may present yet another infrastructure investment opportunity.

Memory and memory architectures are expected to undergo an evolutionary step to accommodate the requirements of AI, and although the timing is somewhat uncertain, a transition to a new technology potentially brings with it both a product and IP investment cycle.

## APPLICATIONS OF AI IN THE MARKETPLACE

Below we discuss some examples of software and services that may be advantaged by AI as well as some examples of industries potentially jeopardized by the proliferation of AI.  Importantly, we believe the ability to proactively identify segments at risk from AI is a benefit increasingly unique to active, research-based managers.

We believe that applications utilizing artificial intelligence will continue to evolve over the next several years.  As mentioned previously, most people have already interacted directly with some form of AI through a recommendation engine, virtual assistant, or chatbot; however, the influence of AI in applications is dramatically more far-reaching.

Many enterprise software vendors have already integrated some AI functionality into their products to help provide advanced analytics, sentiment analysis, or text generation.  At this point, most AI integration has been focused on maintenance automation and process optimization, but its use is expected to proliferate broadly.

IT Services and software development, not surprisingly, have been early adopters.  Many have begun to use AI to facilitate better software development using machine learning and predictive analytics, enabling developers to predict and fix bugs, test software more efficiently, and understand user behavior.

Adoption of AI is not limited to traditional technology companies.  Firms are using AI internally to increase efficiency by automating routine tasks such as data entry, billing and collections, and customer relationship management. The financial services, legal, and real estate industries are beginning to accept AI's ability to provide drafts of basic documents.  The power of AI-enabled predictive analytics also extends into industrial use cases where they can be applied toward preventative maintenance, which will lead to lower maintenance costs and downtime.  According to a recent Ernst & Young survey, 92% of oil and gas companies worldwide are investing in AI or planning to do so in the next two years. And the impact of AI is already evident, as 50% of oil and gas executives are using it to solve challenges across their organization to address subsurface, drilling, and production workflows.  A recent study from Statista (shown below) illustrates the anticipated growth from AI-enabled enterprise applications worldwide through 2025.

Enterprise artificial intelligence market revenue worldwide 2016-2025

**Revenues from the artificial intelligence for enterprise applications market worldwide, from 2016 to 2025 (in million U.S. dollars)**
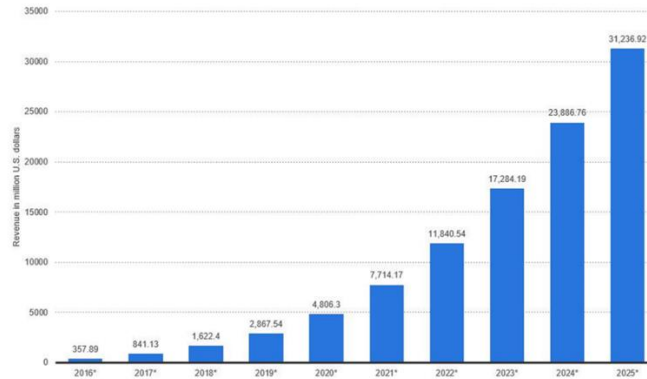


Generative AI models (ChatGPT being the most well-known example) hold immense potential in revolutionizing content creation by autonomously generating novel and high-quality content, mimicking human-like creativity based on learned data patterns. This technology can reduce manual workload and accelerate dynamic content creation and personalization in fields like digital marketing, entertainment, design, and journalism. The ability to rapidly and convincingly create stylized images based on consumer sentiment, summarize large volumes of text, and create realistic voice-overs can provide enormous efficiency within the entertainment, journalism, marketing, and graphic design segments.

## CHALLENGES AND CONCERNS

It is important to recognize, however, these efficiencies can carry risks – and costs. The efficiencies AI could potentially deliver may well come with meaningful dislocations in the job market within those industries. Impacts have already been felt in the education technology sector as AI homework assistance proliferates. As an aside, this impact occurred even given the current limitations of AI technology, where in the absence of a direct "answer," the system will "hallucinate" and essentially make one up. As compelling as the thought of AI is, users must be able to trust the output it provides or its application to high-value problems may be more limited.

The "hallucination" problem notwithstanding, AI faces several potential issues as its evolution continues. One of the most direct challenges is the nature of the data used to "train" the system. In traditional programming "garbage-in garbage-out" referred to the program itself. In the case of AI, if the training data is corrupted, incorrect, or intentionally misleading, the model would provide incorrect, incoherent, biased, or dangerous responses. Additionally, there is an ever-present risk of AI being used for cyberattacks, through some form of coordinated attack, or simply a prolific

misinformation campaign.  Data protection and integrity, already important across the IT spectrum, will become increasingly so.  Lastly, AI (at least to this point) has grown unfettered by regulation.  Whether a technology like AI should evolve without guardrails is a subject for debate at another time, investors (and society) must accept the reality that in the face of AI's power, regulation of some kind in the future is probable.

## WE WILL SAY "WE REMEMBER WHEN...."

Investors (and society in general) from different eras remember certain moments from their past when they saw their world change.  Whether that moment was represented by the fax machine, the cellphone, the personal computer, the iPod, or the Internet, the timeline would be denoted by "before the..." and "after the...."  We believe that machine learning and AI are delivering that moment right now.  Listening to the headlines, it is easy to conclude the winners in the AI race have already been decided, and they are the large- and mega-cap names we have come to expect.  Investment opportunities are not limited to large language models or processing chips and Emerald contends there are AI-exposed investment opportunities across the entirety of the capitalization spectrum, and many remain unrecognized, with their market opportunity just emerging.  AI systems are driving innovation and technological evolution to support the infrastructure required - and those innovations span materials, semiconductor packaging, power, cooling, datacenters, communications, and others.  The ability of AI to deliver advanced analytics across a myriad of industries, as well as providing potentially dramatic efficiency gains to vertical applications, will drive market share shifts that have yet to occur; and there will certainly be winners and losers.  Emerald continues to assert that through active, bottom-up, fundamental research can investors proactively identify these growth opportunities that rarely get the name recognition of their large- and mega- cap brethren.

## AI VIA EA: THE EMERALD ADVANTAGE

As a firm with over 30 years of experience in fundamental, bottom-up, small-cap growth research, we believe our team of analysts and portfolio managers have demonstrated our ability to proactively identify AI beneficiaries and deliver related investment opportunities to our clients across small, mid, and all cap portfolios, and we expect to continue to deliver on our clients' behalf as AI evolves and proliferates further into our daily lives.

## IMPORTANT DISCLOSURE

This report is furnished for the use of Emerald Advisers, LLC, its affiliates and its clients and does not constitute the provision of investment, legal or tax advice to any person. It is not prepared with respect to the specific investment objectives, financial situation or particular needs of any specific person. The information contained in this report was obtained from sources deemed reliable. Such information is not guaranteed as to its accuracy, timeliness or completeness by Emerald. Any opinions contained in this report represent the judgment of the authors as of the publication date. The information contained in this report and the opinions expressed herein are subject to change without notice. Past performance is no guarantee of future results. Neither the information in this report nor any opinion expressed herein constitutes an offer nor recommendation to buy or sell any security or financial instrument. Accounts managed by Emerald's affiliated advisory firms may take positions from time to time in securities discussed in its reports.

**Stephen Amsterdam**

Portfolio Manager &
Senior Research Analyst

Mr. Amsterdam is a Portfolio Manager of the Emerald Mid Cap Growth and Emerald Growth Opportunities portfolios. He is also a Senior Research Analyst and a member of the Emerald Advisers Technology Research Team. He has been with Emerald since 2001 and currently focuses his efforts on network infrastructure, optical technologies, embedded electronics, and unified communications. Prior to joining Emerald Asset Management, Mr. Amsterdam spent a decade investing in, and advising, early stage technology companies as a founding managing director of PA Early Stage Partners, a $50M early stage venture capital fund and senior associate of TLVentures, an $800M venture capital fund associated with Safeguard Scientifics, Inc. He is a graduate of Lehigh University.

**Derek Fisher**

Director of Technology
Research

Mr. Fisher is a Senior Analyst, for Emerald Research. Mr. Fisher focuses his research efforts on emerging growth companies in the Computer Software, Information Technology, Professional Services, Healthcare Services and Medical Devices industries. He began his career at Emerald as an intern in 1995. Due to his generation of ideas, networking and due diligence skills, he progressed to Research Analyst in 1996 and to Senior Research Analyst in 2000. Prior to joining Emerald, Mr. Fisher attended the University of Delaware.

**Nathan Jones, PhD, MBA**

Research Analyst

Dr. Jones is a Senior Research Analyst for Emerald Advisers, focusing on Technology. He joined the firm in the summer of 2013 after a postdoctoral fellowship in melanoma research and nanotechnology at the Penn State College of Medicine. Dr. Jones received his PhD in Pharmacology in the spring of 2012 from the Pennsylvania State University, Hershey Medical Center. He has authored papers in the fields of pharmacogenetics, cancer research, nanotechnology, and drug metabolism. He received his MBA from the Pennsylvania State University in 2009, where he was inducted into the Beta Gamma Sigma National Business Honor Society. Dr. Jones received his BS degree in Biochemistry and Molecular Biology from Penn State University in 2006.

# CONTACT US

Emerald Advisers, LLC

Phone: 1-800-722-4123
info@teamemerald.com

3175 Oregon Pike | Leola, PA 17540
King of Prussia, PA

**TO LEARN MORE ABOUT EMERALD OR TO SCHEDULE
A CALL WITH OUR TEAM, VISIT:**

**WWW.TEAMEMERALD.COM**