

Know Your AI and Robotics Exposure

An Investor's Guide to Investing in the
Symbiosis of AI and Robotics.

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This guide is designed to help investors evaluate their exposure to the dynamic and rapidly evolving fields of Artificial Intelligence and robotics. By breaking down the key layers within these technologies—from foundational hardware to advanced software and real-world applications—this guide equips investors with the knowledge to identify whether their current AI and robotics funds are effectively targeting the right growth areas. Understanding these nuances will help investors differentiate between funds that simply track popular themes and those strategically positioned to capture the next wave of value creation.



I. Introduction: Capturing the Next Wave of AI Opportunity

It is now evident to astute investors that **Artificial Intelligence (AI)** and its profound downstream effects on **Robotics** are driving a technological revolution poised to reshape all industries globally. The scale of investment in AI has just been staggering, with over \$100 billion needed just to participate in building frontier models (T. Hardware, 2024). And thus far, it has been the *Magnificent 6*—Apple, Amazon, Google, Meta, Microsoft and Nvidia—that have dominated headlines as they have sought to expand and enhance their data centres with Nvidia GPUs.

Consequently, most AI-focused ETFs have concentrated their holdings in these high-profile companies, which have undeniably led the first wave of AI growth and delivered significant returns to investors. If investors believe that the Magnificent 6 will continue to dominate the AI landscape—and there is a compelling argument for their continued leadership given the scale of their investments—then we believe they are well-positioned by maintaining exposure to the Nasdaq 100 as a core technology benchmark.

However, if investors are open to the possibility that the next wave of AI growth may also come from companies outside of the Magnificent 6—as we are confident it will, based on our decade of research into disruptive technologies, which has identified significant asymmetries and untapped opportunities across the AI stack—then a uniquely differentiated, actively managed *satellite* AI ETF could be an excellent complement to investors' portfolios.

The challenge we currently see in Europe, however, is that most AI-themed ETFs are merely Nasdaq 100 proxies, exhibiting near-perfect correlation. This raises questions about whether paying 50-75 bps for an AI-themed ETF is truly justified. For this reason, we believe investors should actively seek differentiated exposure by thoroughly questioning their fund manager about their genuine 3-, 5-, and 10-year convictions and how their portfolio is positioned for this new technological supercycle.

In this guide, our aim is to help investors identify the key factors to watch for when evaluating and comparing artificial intelligence and/or robotics ETFs, ensuring their investments are well-positioned for long-term success.

II. Your Artificial Intelligence Exposure: Key Factors to Consider

We begin by examining the artificial intelligence sub-theme. Investors must understand how their chosen AI exposure captures value across the AI ecosystem. If they already hold a fund, they should demand clarity from their fund manager on where the fund is positioned within the AI stack, why, and to what extent. The AI stack includes foundational technologies like semiconductors and data centres, platform applications, software services, and robotics integration. This understanding is key to determining if a manager truly grasps AI's transformative potential, rather than simply chasing trends.



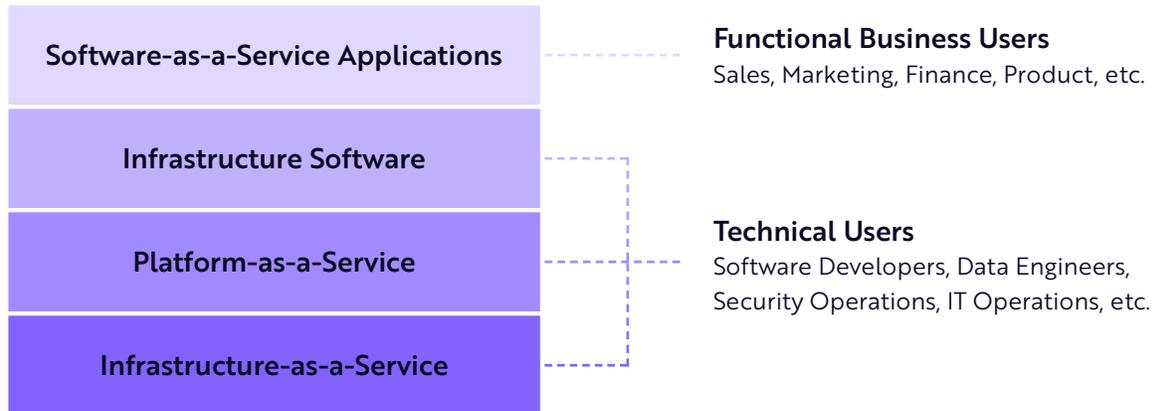
A. Understanding your Exposure across the AI Stack

The AI stack can be divided into four main layers: Compute (Chips), Infrastructure-as-a-Service (IaaS), Platform and Infrastructure Software (PIS) and Software-as-a-Service (SaaS). Each layer plays a distinct role in the development and deployment of AI, offering investment opportunities with varying levels of growth and risk.

- **Compute (Chips):** This foundational layer provides the processing power required to run AI models. Companies like Nvidia and AMD are at the forefront of this space, developing advanced AI chips that are essential for training and deploying machine learning algorithms. As AI adoption accelerates, the demand for high-performance computing will grow, making this segment a crucial part of the AI stack.
- **Infrastructure-as-a-Service (IaaS):** Above compute, IaaS provides the cloud infrastructure that allows businesses to access AI hardware and computing resources on demand. Major players like Amazon Web Services (AWS), Microsoft Azure, Google Cloud and Oracle Cloud dominate this space, enabling companies to scale their AI operations without investing in costly physical infrastructure. While IaaS is essential for the AI ecosystem, the market is heavily concentrated among these providers, which can limit its growth potential compared to other layers of the stack.
- **Platform and Infrastructure Software (PIS):** Sitting atop Infrastructure-as-a-Service (IaaS), the PIS layer provides the essential tools and platforms developers use to build, deploy and manage AI applications. Companies like Databricks and Palantir lead the way in managing and analysing vast datasets through their innovative platforms. Palantir, for instance, is positioning itself as the operating system for government and enterprise AI applications, with its AIP Now service offering ready-to-use solutions similar to an app store, enabling rapid deployment across various enterprise functions. By providing a unified platform for data integration, analysis and decision-making, Palantir helps organisations leverage AI to enhance operational efficiency and strategic planning.
- **Software-as-a-Service (SaaS):** At the top of the stack, SaaS delivers AI-powered applications directly to end-users. Companies like HubSpot and SAP offer solutions that automate and optimise customer relationship management and business operations. While SaaS plays a critical role in AI's adoption, the rise of Platform and Infrastructure Software and custom AI platforms may challenge traditional SaaS offerings as businesses demand more tailored, scalable solutions.



AI Stack Breakdown



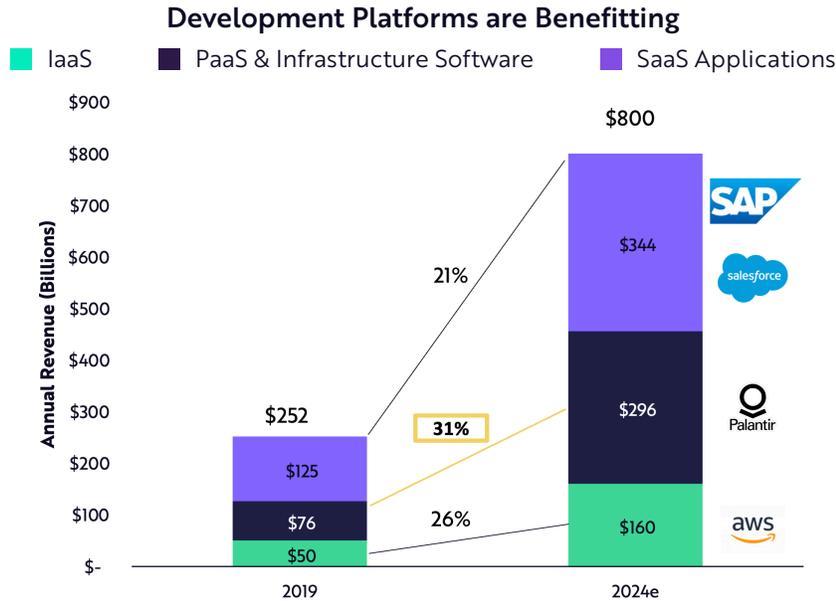
→ Why it Matters

We believe that understanding where an AI fund invests across the AI stack is crucial for assessing its growth potential and risk profile. Many AI-focused funds allocate heavily toward the compute and IaaS layers, resulting in excessive exposure to mega-cap tech. While these companies may provide consistent, steady growth, they often lack the asymmetric upside that we—and many others—see today in AI software companies within the PIS and SaaS layers of the AI stack. As companies increasingly seek to leverage their underutilised data and enhance operational efficiency through AI, software applications will be essential enablers of adoption. We believe that fund managers who are diversified across the AI stack, with a greater emphasis on PIS, will be best positioned to capitalise on the next wave of AI opportunity.

→ Our Approach

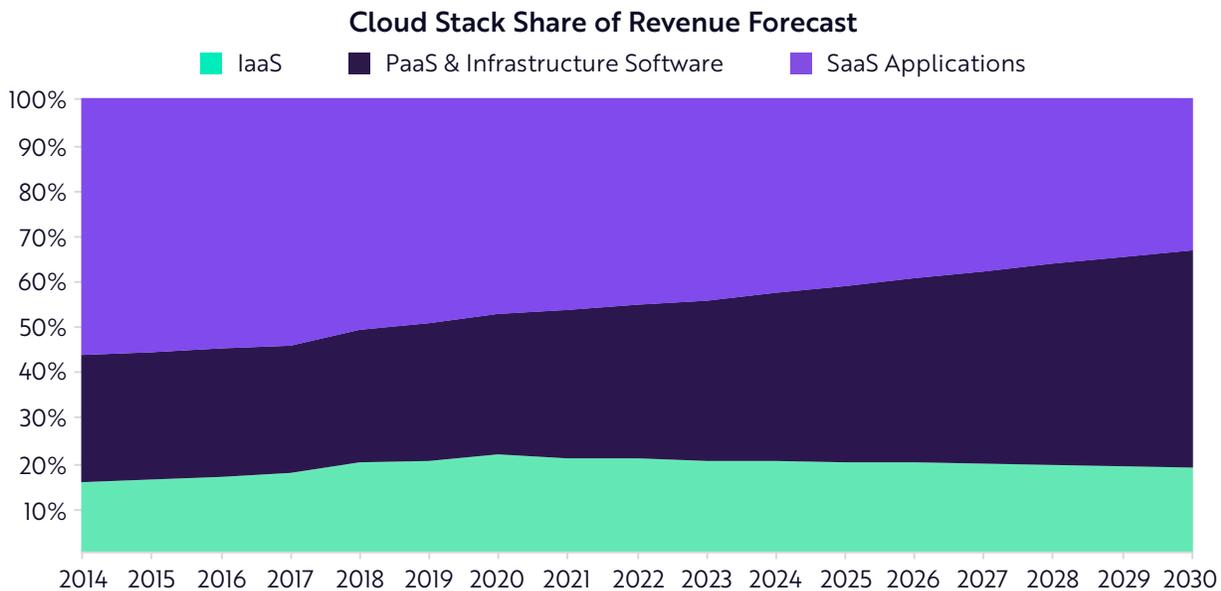
We project that PIS companies will be the strongest growth engines of the AI stack. Accordingly, our investment process prioritises PIS companies.

Between 2019 and 2024e, PIS has achieved a CAGR of 31%, outpacing both IaaS (26%) and SaaS applications (21%). This growth has been fueled by the rapid expansion of cloud deployments, but we believe the next phase of growth will be driven by new catalysts beyond cloud adoption.



Sources: ARK Investment Management LLC, 2024, based on data from SWE-Bench and IDC with data as of August 7, 2024.

Advancements in AI are expected to accelerate growth across cloud and software ecosystems, with projected growth rates ranging from 34% to 54% in an optimal bullish scenario by 2030. PIS is expected to capture the largest market share as AI increasingly reduces the marginal cost of creating custom software solutions. This shift positions data and application platforms to benefit further, while traditional SaaS incumbents face risks as businesses seek more customised, AI-driven solutions. While we expect the size of the pie (i.e., the total addressable revenue) to increase dramatically, our research shows that PIS will increasingly take market share relative to other areas of the cloud tech stack.



Sources: ARK Investment Management LLC, 2024. This ARK analysis is based on a range of underlying data from external sources, which may be provided upon request.



Peer Comparison

Illustrative Exposure	Hardware	IaaS	PaaS	SaaS	Robotics	Add'l AI	Other	Total	Top 10	Style
ARK Artificial Intelligence & Robotics UCITS ETF	11%	3%	26%	10%	29%	20%	0%	100%	49.4%	Active
Amundi MSCI Robotics & AI ESG Screened UCITS ETF	34%	5%	21%	18%	15%	4%	3%	100%	35.5%	Passive
Xtrackers Artificial Intelligence & Big Data UCITS ETF	36%	9%	20%	19%	0%	5%	11%	100%	48.8%	Passive
WisdomTree Artificial Intelligence UCITS ETF	51%	1%	13%	22%	7%	5%	1%	100%	29.1%	Passive
L&G Artificial Intelligence UCITS ETF	25%	5%	27%	25%	6%	7%	3%	100%	21.5%	Passive
L&G Robotics & Automation UCITS ETF	66%	0%	0%	13%	20%	1%	0%	100%	19.6%	Passive
iShares Automation & Robotics UCITS ETF	46%	0%	5%	34%	16%	0%	0%	100%	25.7%	Passive

Source: ARK Invest Europe. Categorisation is subject to change over time. Data as of 2024.

B. Hardware-to-Software Evolutions in Technology Cycles

The history of technology has shown us that hardware breakthroughs often lay the foundation for transformative software innovations. This pattern has repeated across multiple cycles, with companies emerging as leaders in both phases and the same is true today for Artificial Intelligence. For investors, it is important to see the bigger picture of how past technological revolutions mirror what is happening now with AI. In this section, we explore historical examples of this hardware-to-software progression, offering insight into the broader technology landscape for those less familiar.

Hardware Phase

Historically, major technological shifts began with advancements in hardware:

- IBM and Apple were pioneers in the personal computing revolution. IBM introduced the IBM PC in the early 1980s, while Apple revolutionised consumer technology with the Macintosh in 1984.
- In the smartphone revolution, Apple redefined mobile hardware with the iPhone in 2007, while Samsung became a leader in Android-powered hardware.
- The semiconductor industry, driven by Intel and Nvidia, provided the backbone for modern computing. Intel led with CPUs, while Nvidia transformed graphical computing with GPUs, setting the stage for advancements in AI.
- In consumer electronics, companies like Sony and Panasonic dominated with innovations in TVs, audio systems and gaming consoles.



Software Phase

Once hardware reaches maturity and mass adoption, attention typically shifts to software, where much of the value is realised. The development of AI follows a similar path:

- Following the hardware-driven PC revolution, Microsoft capitalised by developing software such as Windows and Office, making them essential tools in the business world.
- Google leveraged the internet revolution by creating the Android operating system, a platform now used by billions of smartphones globally.
- The rise of cloud computing abstracted hardware infrastructure into virtual platforms, allowing companies like AWS and Google Cloud to enable new software services and applications.

For AI, the hardware phase laid the groundwork, but software advancements in areas like PaaS and SaaS now play a crucial role in delivering value. This mirrors the historical progression of past technological cycles.

Current Trends

Today, AI exemplifies the convergence of hardware and software, and this fusion is transforming entire industries:

- Companies like Tesla and Nvidia have driven hardware advancements in AI chips and self-driving technology, while software leaders like OpenAI and Google DeepMind are building on this foundation to create sophisticated AI models.
- Palantir and Databricks are leaders in platform infrastructure software, enabling businesses to extract value from their vast datasets. These companies bridge the gap between AI hardware (e.g., Nvidia chips) and actionable AI-driven insights.

This convergence underscores the importance of understanding how AI exposure is positioned across the technology stack, from hardware to software, as discussed in Sections 2 and 2.A.

Hardware Companies Expanding into Software

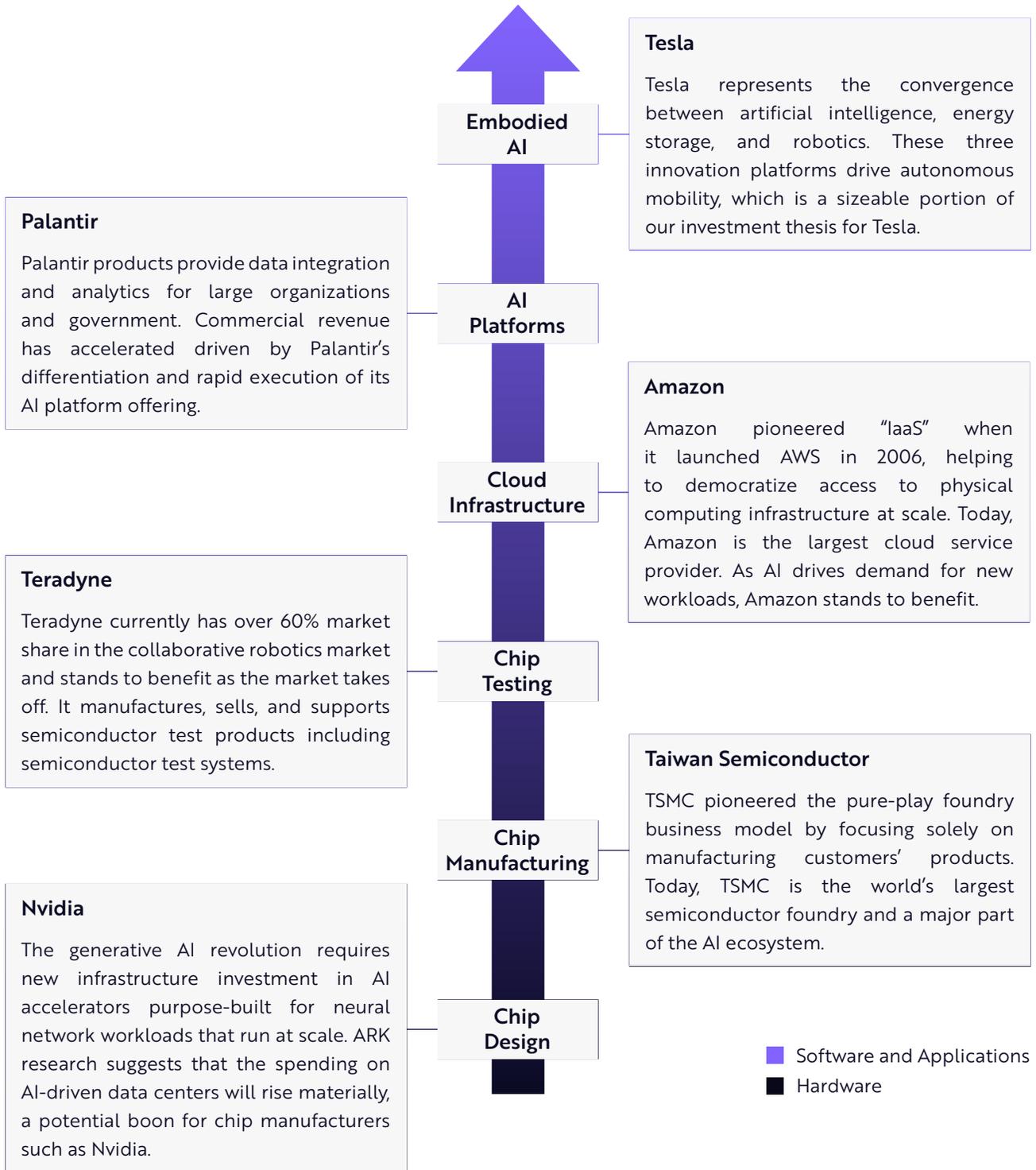
History shows that even hardware-focused companies often evolve into software ecosystems. Apple and Nvidia exemplify this trend:

- Apple, initially known for its hardware innovations, now derives much of its value from software services like iOS and the App Store.
- Nvidia, after establishing dominance in GPU hardware, expanded into AI software through platforms like CUDA, supporting advancements in machine learning and data science.

This hardware-to-software transition parallels what is happening in AI space today, where leading companies are evolving to capture value at every level of the stack.



AI Value Chain: From Hardware to Software



Note: We selected the most representative companies based on market share & product leadership in each of the respective categories. Source: ARK Invest. Data as of May 31, 2024. Data and investment theses are subject to change.



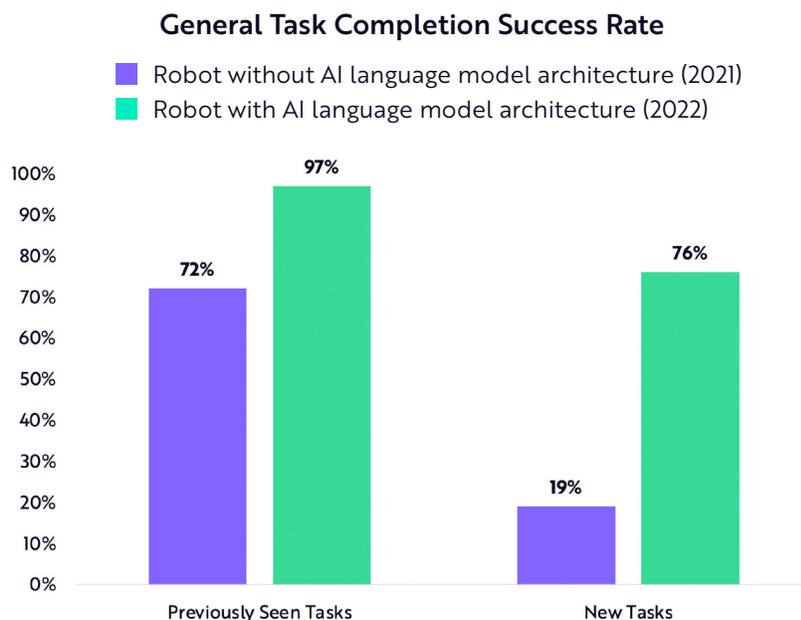
III. Your Robotics Exposure: Key Factors to Consider

Next, we turn to the Robotics sub-theme. Over the past decade, many robotics innovations, such as the Roomba, have struggled to achieve large-scale adoption. However, the convergence of robotics and AI is now acting as a catalyst, unlocking transformative opportunities across industries like autonomous vehicles and drones. This shift marks a turning point for robotics, enabling unprecedented scale and efficiency. We believe investors should actively seek out fund managers who understand these converging technologies and can identify the significant opportunities they present—positioning portfolios to capture the next wave of growth.

A. How is AI Driving the Robotics Opportunity

Computing infrastructure, machine learning, autonomous navigation, sensors and perception, and actuators and mechanics are driving the next wave of opportunities in robotics. We see the convergence of AI and robotics as ‘Embodied AI’—the application of AI in the physical world, which contrasts with the productivity gains achieved by enhancing knowledge worker efficiency, as discussed in the previous section.

Importantly, the incorporation of large language models into robotic processes has significantly increased effectiveness, not only for previously familiar tasks but also for new tasks on which robots have yet to be trained. Transformer architecture, a cornerstone of this decade’s AI revolution, has been the key driver of this stepwise increase in capability.



Sources: ARK Investment Management LLC, 2023. Gopalakrishnan, K. et al. 2022; Brohan, A. et al. 2022; Jang, E. et al. 2022. Compares performance of RT-1, the robotics transformer architecture to BC-Z, based on a recurrent neural net architecture. Forecasts are inherently limited and cannot be relied upon.



B. Understanding your Allocation to Robotics

Robotics has historically been concentrated in industrial manufacturing, with **early-stage applications** in industrial automation (like auto manufacturing), logistics and supply chain robotics (e.g., warehouse robotics) and surgical robotics (e.g., Intuitive Surgical).

However, **advanced applications** are now emerging, including autonomous vehicles, drones and agricultural robotics, along with collaborative robots designed to work alongside humans. We believe this is the most exciting investment opportunity when applying a five-year time horizon to the public equity markets.

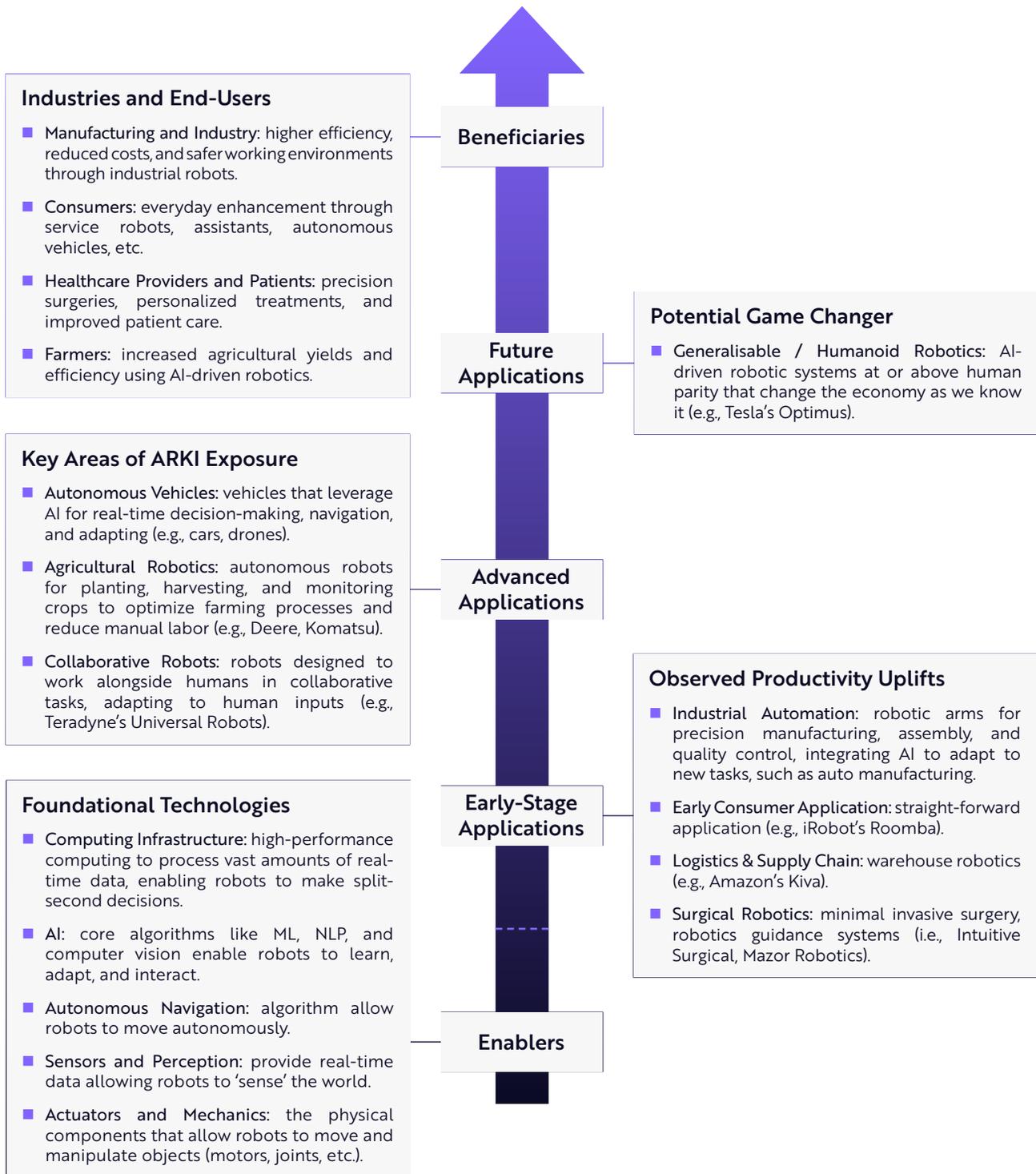
Looking ahead, **future applications** such as humanoid robots capable of operating at or above human parity have the potential to fundamentally reshape the economy as we know it. If humanoid robots are able to operate at scale, they could generate ~\$24 trillion in revenues, split roughly equally between household and manufacturing robotics (ARK Investment Management LLC, 2024).

Understanding how these applications are evolving, driven by the convergence of AI and robotics, is essential. Investors should seek fund managers who recognise where robotics has been, where it is headed, and how to capitalise on the massive market opportunities arising from this convergence.

The diagram on the following page depicts the opportunity timeline.



Embodied AI: Robotics Brings AI to the Physical World



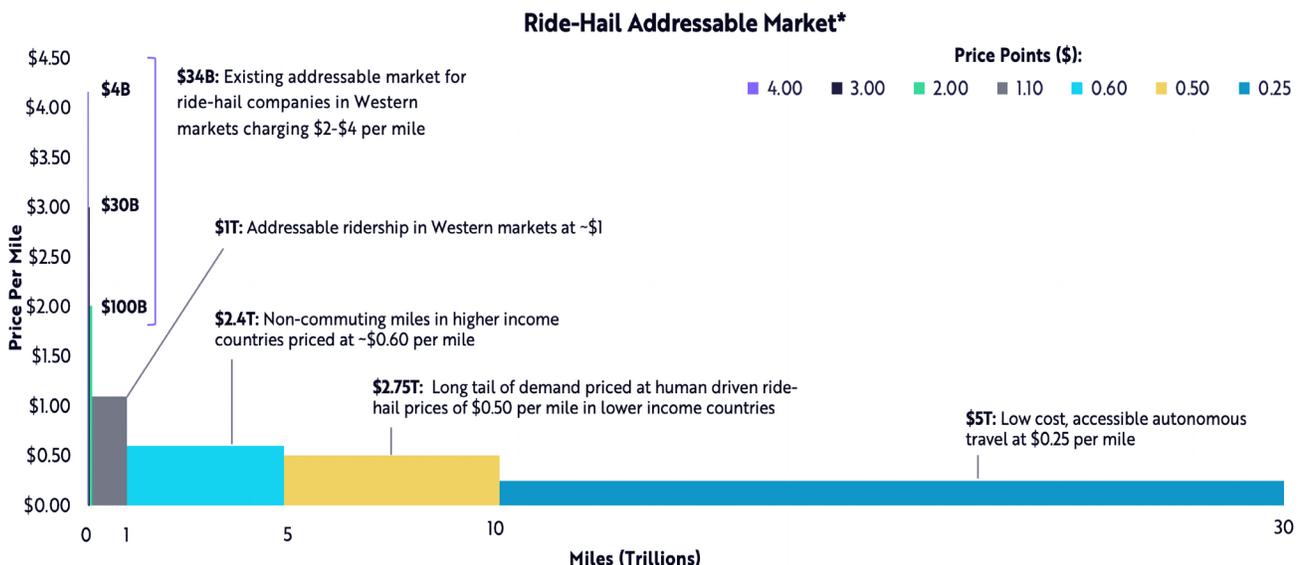
Note: We selected the most representative companies based on market share & product leadership in each of the respective categories. Source: ARK Invest. Data as of May 31, 2024. Data and investment theses are subject to change.



→ Why it Matters

We believe that understanding where one’s exposure lies along the robotics opportunity timeline above is crucial for assessing expected growth. For example, our research indicates that autonomous ride-hailing is on track to create an \$11 trillion addressable market. At \$0.25 per mile, autonomous transportation could serve a much broader population compared to human-driven ride-hailing today. Meanwhile, given the value consumers place on their time, significant demand could also exist at higher price points.

Despite the scale of this opportunity and the advances made in recent years, few robotics fund managers appear to currently incorporate this exposure in their portfolio positioning. Instead, our research suggests that most robotics fund managers remain focused on early-stage applications, which we believe represent smaller opportunities and more mature markets.



*\$11 Trillion is the addressable market, not the revenue we expect in 2030, as we do not expect autonomy to penetrate all addressable miles. Sources: ARK Investment Management LLC, 2024. This ARK analysis is based on a range of underlying data from external sources, which may be provided upon request.

→ Our Approach

Accordingly, our investment process in robotics prioritises enablers, leaders, and beneficiaries within Embodied AI. Our high-conviction approach emphasises advanced applications as the key focus area within robotics. Top holdings like Tesla are directly aligned with the autonomous vehicle opportunity—which we view as the world’s largest AI project—while companies like Deere are advancing autonomous applications in agriculture. Additionally, holdings such as Iridium Communications and Rocket Lab are building networks of low-Earth orbit satellites that will enable Embodied AI to operate on a global scale.



IV. Overview of the ARK Artificial Intelligence & Robotics UCITS ETF

The ARK Artificial Intelligence & Robotics UCITS ETF provides investors with high-conviction exposure to the companies driving the next wave of AI and Robotics innovation. By focusing on Platform and Infrastructure Software and Embodied AI, we believe we offer a more forward-looking approach than many AI funds, which remain over-weighted in the “Magnificent 7”.

Key Features:

- **High conviction:** high conviction portfolio of 30-60 stocks focusing on our best ideas in AI and robotics.
- **AI software emphasis:** a unique primary focus on platform and infrastructure software, where the highest growth potential exists.
- **Embodied AI through robotics convergence:** exposure to companies at the forefront of the convergence between AI and robotics, capturing real-world, advanced applications across industries.
- **A portfolio solution:** due to our highly active approach, our positioning is well-differentiated relative to common benchmarks with an active share of 77% to the Nasdaq 100 Index. As a result, the addition of our strategy to a core portfolio represents minimal overlap, a true diversifier, and a forward-looking approach to identifying the next wave of value accrual across AI and robotics.
- **Market cap:** predominantly exposed to large-cap companies (~70%), with less exposure to mid- and small-caps compared to many other thematic funds.

By investing in the ARK Artificial Intelligence & Robotics UCITS ETF, you gain access to a diversified, strategically positioned portfolio that seeks to capture the future growth potential of the Artificial Intelligence and Robotics sectors.



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Rahul joined ARK in September 2023 following ARK's acquisition of Rize ETF (now ARK Invest Europe), of which he was co-founder and director. Rahul is a managing director and global head of index in Europe as well as director on the board of the ARK Invest UCITS ICAV. An expert strategist in thematic and sustainable investments, Rahul is responsible for spearheading global systematic (self-indexed) strategies, overseeing European UCITS product strategy and implementation, and leading investment research alongside managing our product specialist team. His research focus includes the energy transition, food sustainability, and the digital economy.

Prior to ARK Invest Europe, Rahul served as Co-Head of ETF Investment Strategies at Legal & General Investment Management (LGIM), a platform LGIM acquired from ETF Securities in 2018.



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Thomas joined ARK in June 2021. As Client Portfolio Manager, Thomas works directly with ARK's investment team to communicate in-depth knowledge of investment-level detail to internal and external clients.

Prior to ARK, Thomas was Vice President, Lead Portfolio Manager within the multi-asset solutions business at Goldman Sachs Asset Management for over five years where he managed customized portfolios for institutional clients. Prior to joining Goldman Sachs in 2015, Thomas held various client-facing positions at MSCI Inc. over the span of four years, with a key emphasis on business development within the exchange-traded funds team. Thomas is a CFA charterholder, and earned his Bachelor of Arts in International Affairs and Management & Business from Skidmore College.

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