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Robotics at the Crossroads: Entering a New Era, Fueling a Global Boom, and Backing ROI-Driven Startups

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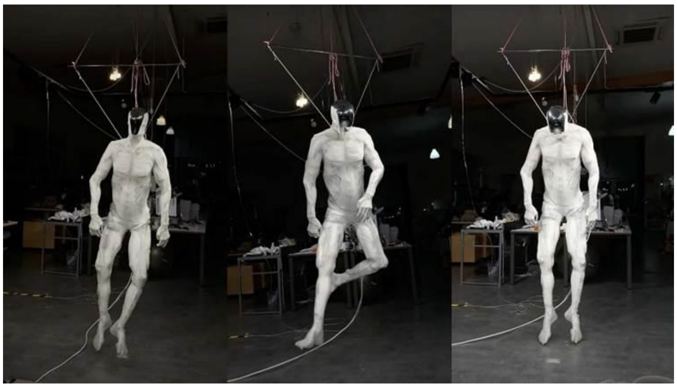
In February 2025, Clone Robotics unveiled Protoclone, a highly realistic humanoid robot with 206 bones, 1,000 synthetic muscles, and artificial ligaments, designed to mimic human biomechanics. Unlike traditional robots, it uses biomimetic actuators that replicate real muscle movement, enabling lifelike motion. This breakthrough marks a key step toward functional humanoid robots for tasks in various industries.



This innovation feels straight out of Westworld. In the series, humanoid robots called "hosts" appear indistinguishable from humans, raising profound questions. Today, Clone's Protoclone signals that what once was science fiction is becoming real: the blend of physical robotics and embodied AI is moving from laboratory curiosity to live prototype.

That said, **we're still in the early days**. Humanlike general-purpose robots remain years away from large-scale deployment, and their capabilities are far from mature.

However, **the true transformation is unfolding behind the scenes** – in industries like manufacturing, healthcare, logistics, and construction – where vertically specialized robots are already creating meaningful impact.

At AVP, we have spent recent months deepening our understanding of this shift. Through conversations with founders and experts, and a deep dive into the evolving robotics stack, we have developed a perspective on where the sector is headed. And our conclusion is that we are convinced about the ability for verticalized, AI-enabled robotics to transform sectors like manufacturing and healthcare and believe they represent strong investment opportunities. With breakthroughs in data infrastructure, computer vision, foundational models, and edge AI, these systems are evolving from narrow tools into intelligent collaborators. As a result, robotics will not just augment human labour, it will set new standards.

In this whitepaper, we explore why robotics is experiencing a pivotal moment, driven by recent technological breakthroughs and growing commercial interest (I). We then provide an overview of the market, focusing on regional shifts and global trends (II). Additionally, we will decode the value chain to understand how robots think, move, and learn (III). Finally, we will present our robotics bet, outlining the key segments we believe are poised for impact and value creation (IV).

I. Why could this be robotics' tipping point?

Over the past decades, robotics has evolved from rigid industrial machines to intelligent, adaptive systems. The 1960–1980 period marks the beginning of industrial robots and automation in manufacturing, with Unimate as the first robot deployed at General Motors. In the 1990s–2000s period, robots began leaving factory floors with Roomba entering homes and Honda's ASIMO showcasing humanoid mobility. Since the 2010s, breakthroughs in computer vision, machine learning, and AI have dramatically expanded robotics' capabilities. Boston Dynamics introduced agile, bipedal robots like Atlas, and robots are now used widely in logistics, agriculture, and healthcare.

This historical progression has shaped the diversity of robot types we see today. **In robotics, form naturally follows function:** designs are optimized for the tasks they perform, much like software interfaces are tailored to specific use cases. As a result, robotic arms dominate in manufacturing, cobots are built to work safely alongside humans, AMRs support logistics, quadrupeds handle inspection, and service robots find applications in domestic or retail settings. At the frontier, humanoid robots aim to replicate human form and dexterity to operate in environments built for people, though this path remains early and capital intensive.

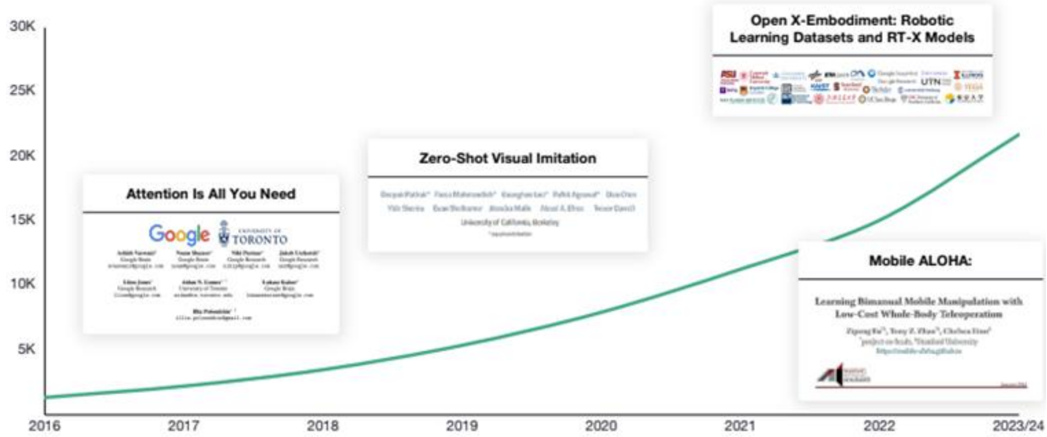
Yet despite this progress, **robotics has long struggled to fulfil its broader promise**. The industry faces deep and persistent limitations.

- First, **robotics is fundamentally hard**: it sits at the intersection of hardware and software, where progress in one is often constrained by the other. Hardware is costly, complex, and brittle – even small changes can throw off performance.
- Second, **robotics suffers from the Moravec paradox**: what's easy for humans (like grabbing a ripe fruit) is extremely difficult for robots, while tasks that are computationally intensive (like playing chess) come far more naturally for them.
- Third, **on the software side, robots often lack the generality needed to operate in dynamic, unstructured environments**. Most systems today are narrowly programmed for specific tasks and adapting them to new use cases remains a major challenge.

As a result, while robot demos may look impressive, real-world deployment is still constrained by cost and the complexity of integrating robots into diverse workflows.

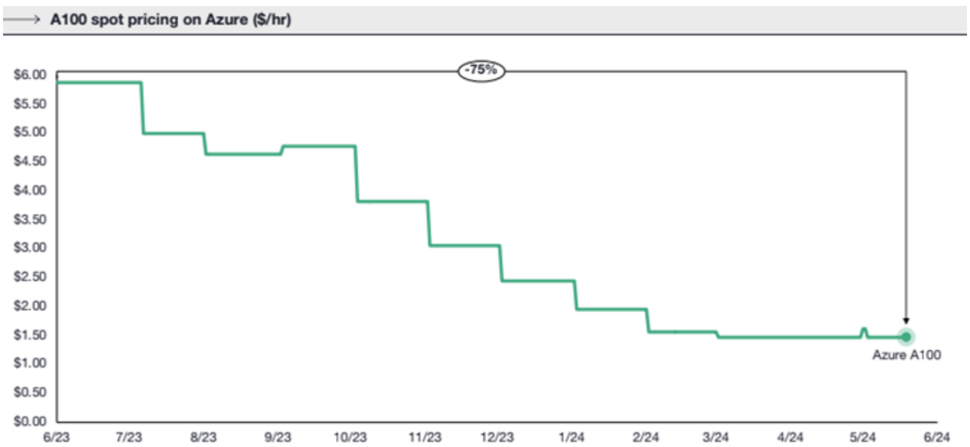
Fortunately, several key factors are accelerating the shift from robotic prototypes to real-world deployment:

- **Research and talent momentum:** Robotics research has exploded, with publications rising from under 2k in 2016 to over 20k in 2023. Talents from top academic institutions are now founding startups: Berkeley and Stanford researchers launched Physical Intelligence and MIT spun out Cobot.



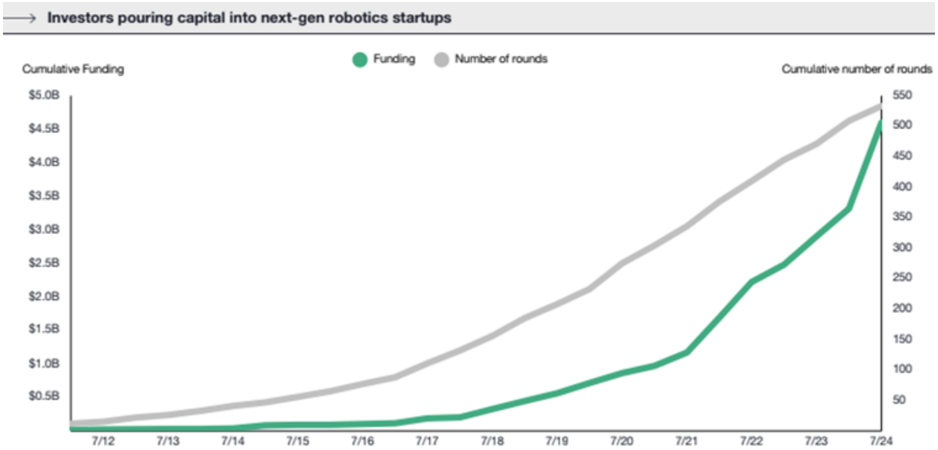
[Evolution of research publications in robotics]

- **A more modular robotics stack:** Tools like ROS2, PX4, and Ardupilot are making it easier for startups to build on top of shared infrastructure. Instead of reinventing the wheel, teams can now focus on vertical applications.
- **Cheaper hardware:** The cost of training AI models has dropped significantly (GPU costs down circa 75% between 2023 and 2024), making experimentation and iteration faster. Meanwhile, core robot components like LiDAR sensors, batteries, and motors are also becoming more affordable, and almost commodities.



[Evolution of GPU costs]

- **Data and training:** New approaches are being explored to train robots more effectively. Teleoperation, AR data, simulation environments, and video-based learning all show promise.
- **Advances in spatial AI models:** Just as LLMs enable reasoning over text, spatial AI models are starting to enable reasoning in the physical world. These systems can interpret multiple data modalities, understand relationships between physical objects, and learn how to act within complex environments. Recent demonstrations, such as OpenAI's robot hand solving a Rubik's Cube, have shown that AI can generalize across physical tasks – leading many to believe a "ChatGPT moment" for robotics may be on the horizon.
- **Surging investment:** Funding for robotics startups has surged, reflecting growing investor conviction.



Evolution of fundings for AI robotics startups

In short, while robotics has long struggled to break out of narrow use cases, a convergence of advances in AI, hardware, and software is beginning to shift to that reality. The field is gaining momentum, and early signs point to a new generation of robots that are more capable, adaptable, and scalable than ever before.

To better understand where this momentum is heading, **we now turn to the structure of the robotics market – examining emerging trends across key geographies.**

II. Understanding the robotics market: global trends and regional shifts

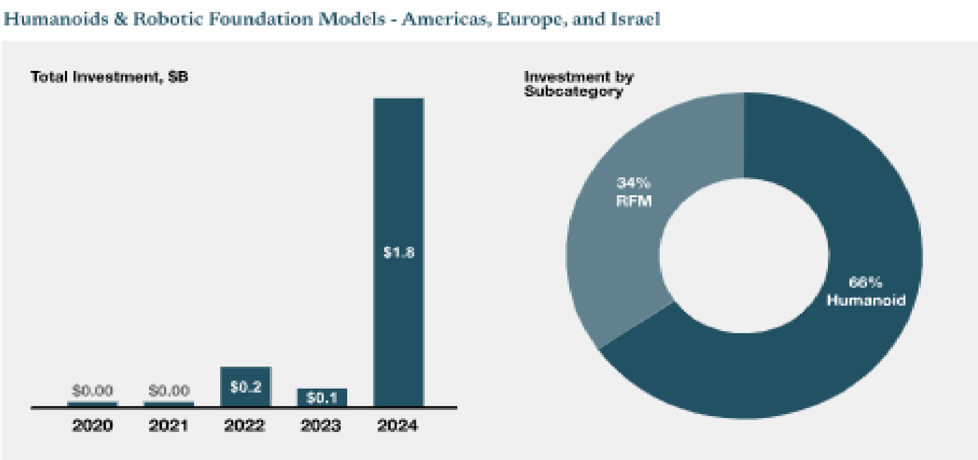
Over the past decade, robotics adoption has followed a generally steady, linear trajectory. In industrial settings, the number of robots per 10k manufacturing employees tripled between 2013 and 2022, reflecting the gradual integration of automation into factory workflows. In the consumer market, adoption has also risen sharply, with cumulative home robot shipments surpassing 30m units by 2023, driven largely by devices like robotic vacuum cleaners. These trends point to growing acceptance and utility of robots in both professional and personal contexts. However, with recent breakthroughs, we may be approaching an inflection point, where adoption accelerates beyond the historical pace.

While adoption has broadened, **the geopolitical landscape of robotics is also something to consider**, with US and China increasingly leading the race.

- **In Europe, robotics progress is uneven.** Despite having world-class research institutions and industrial heritage, the continent is hampered by regulation (AI Act and EU Machinery Regulation), insufficient access to growth capital, and slower commercialization cycles. One conclusion of the Draghi report is that, to remain competitive, significant funding is needed in Europe in new technologies such as AI, quantum computing, but also robotics, as well as deregulation.
- In sharp contrast, **China is quickly establishing itself as a global powerhouse in robotics,** driven by a combination of government policy, industrial strength, and rapid progress in AI. The country is also responding to rising wage inflation, which has put pressure on its traditional low-cost manufacturing advantage. Robotic automation is seen as a strategic solution, and steps

- are being taken to accelerate adoption. Central and local governments offer subsidies and R&D incentives to local manufacturers to help them automate – circa 17.5% of the equipment cost for robot purchases. Across the country, dozens of robotics startups are developing advanced systems with capabilities such as computer vision and autonomous navigation. These robots are being deployed in diverse sectors like manufacturing and logistics. Major manufacturers such as Foxconn have integrated robots into their operations, and several robotics firms have gone public, including Horizon Robotics. This growth also reflects the strategic aspect of maintaining industrial competitiveness in a higher-wage economy.
- Meanwhile, **the US continues to lead in next-generation robotics**, driven by a convergence of top-tier academic institutions, mature capital markets, and strong entrepreneurial ecosystems. The US robotics and AI market reached an estimated $5bn in 2024, and is expected to grow at a 22% CAGR, reaching nearly $39bn by 2034. American firms are particularly dominant in humanoids and robotic foundational models, which have attracted massive funding rounds. Companies like Figure, 1X, and Physical Intelligence have each raised hundreds of millions of dollars, positioning the US at the forefront of advanced robotics R&D. Big Tech players are also stepping in: Tesla (Optimus) has doubled down on humanoids; Amazon continues to automate logistics; and companies like Google and Meta are actively investing in robotics as part of broader AI strategies. Maintaining the current competitive edge will require continued investment, policy alignment, and clear prioritization at the federal level.

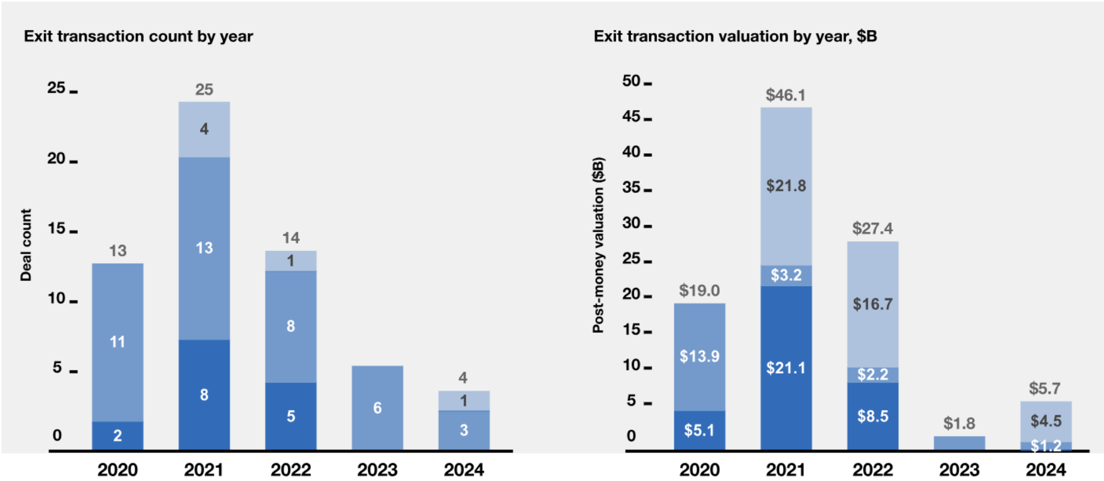
This surge in innovation is matched by record-breaking fundraising activity. The capital-intensive nature of robotics – driven by high R&D costs, talent demands, and complex hardware – has led to large rounds across the board. Notable recent investments include Figure ($675m), Physical Intelligence ($400m), Skild AI ($300m), Agility Robotics ($150m), and 1X ($100m). While many of these companies are still in the early innings, they've secured strong investor backing due to the sector's transformative potential.



Humanoid & Robotic Foundational Models Investments – Americas, Europe, and Israel

On the M&A side, while the activity has been more muted over the past three years, several high-profile deals signal continued interest from strategic acquirers. Transactions exceeding $250m include the acquisition of Clearpath by Rockwell ($609m), Velodyne by Ouster ($600m), Ghost Robotics by LIG Nex1

($400m), Dedrone by AXON ($500m), and Aerodome by Flock Safety ($300m). These deals reflect consolidation in specific verticals – particularly autonomy, sensing, and security – where synergies with incumbent players are strongest. Also, it must be noted that all those transactions are in the US.



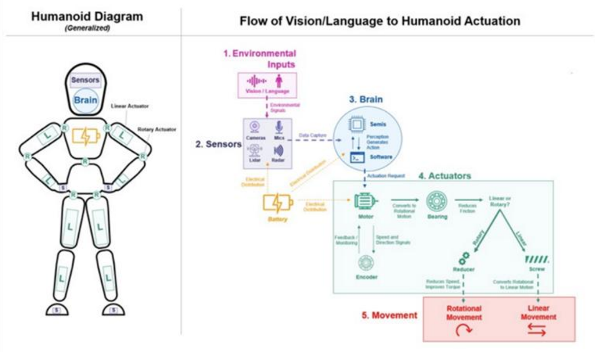
[Robotic Transactions >$25M](#)

In the public markets, listed robotics companies like Procept BioRobotics, Aurora, Symbotic, and Intuitive Surgical command multi-billion-dollar valuations, reflecting investor confidence in the sector's long-term relevance. These signals point to a market entering a new phase – driven by rapid technological progress, geopolitical competition, and increased capital availability.

While adoption has historically been gradual, the growing maturity of the ecosystem – from cutting-edge research to national strategies – suggests that **robotics is becoming a core pillar of global technological transformation**. To understand how this momentum translates into real-world impact, **we now turn to the robotics value chain**, from the "brain" and "body" of robots to the integrators enabling deployment across industries.

III. Decoding the robotics stack: how do robots think, move, and learn?

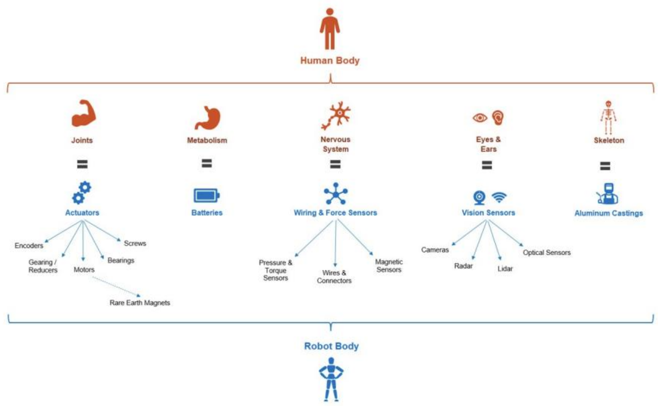
Exhibit 5: Flow diagram of a humanoid robot: Understanding the interconnections between various components and the general role that each plays in the humanoid.



Source: Morgan Stanley Research

When we think about robots, much attention is placed on the "brain" – the AI models and algorithms that power intelligence. But equally important is **the robot body**. Like our bodies, robots rely on integrated systems to move, sense, and operate in the physical world. Actuators function as joints and muscles; batteries serve as their metabolism, and sensors replicate the nervous system and senses. Vision modules act as eyes, while aluminum castings form the skeleton. This physical layer is critical.

Exhibit 13: Dissecting the Humanoid Body



Source: Morgan Stanley Research

A. Hardware Providers

Hardware providers like FANUC, KUKA, and ABB **have played a central role in the development of industrial automation**, supplying robotic arms and motion systems widely adopted in manufacturing environments. Their hardware remains a key enabler for many robotics applications today, particularly in sectors like automotive. However, these systems were historically designed for repeatable, pre-programmed tasks and are only gradually evolving to accommodate the flexibility required by AI. While their manufacturing capacity gives them a head start, **their ability to adapt to defined software will determine how relevant they remain in the next phase.**

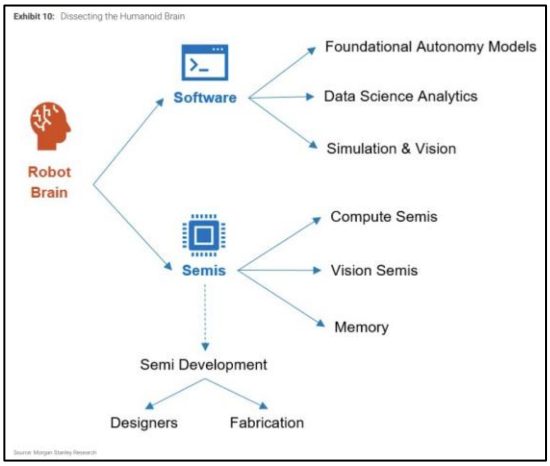
B. Actuators & Sensors

Actuators and sensors are core blocks that enable robots to move and perceive the world around them. Actuators function like muscles, converting electrical energy into motion to support tasks such as walking or grasping. Startups like Kyber Labs are developing artificial muscle fiber actuators that replicate the elasticity and responsiveness of human muscle, aiming to deliver more natural and precise movement at lower cost. On the sensing side, robots rely on a mix of technologies – cameras, LiDARs, radars, IMUs, and odometers – to understand their surroundings. Sonair, for example, uses ultrasound to provide omnidirectional 3D depth sensing, while Cerebionics is developing implantable brain–computer interfaces that could one day bridge neural activity with robotic control. These next-generation actuators and sensors are helping close the gap between robotic and human capabilities in real-world environments.

C. Edge AI: Real-time autonomy at the edge

As robots transition into real-world settings, the need for local, real-time processing is critical. Edge AI enables robots to make decisions without relying on cloud – ensuring low latency, greater reliability, and better data privacy. This is fueling the rise of "Tiny AI": modular, affordable task-specific devices, and privacy-preserving. Startups like Edge Impulse provide a platform for building and deploying ML models on edge; Sima.ai offers high-performance edge AI chips; Stanhope AI focuses on private inference that runs entirely offline; Opteran mimics insect brains to deliver lightweight, energy-efficient autonomy; and Hive Robotics uses edge AI to command, control, and swarm robots. They are contributing to the growing adoption of edge AI solutions in robotics.

As the hardware part continues to evolve – bringing robots closer to human-level perception and motion – they lay the foundation for more capable and intelligent machines. But it's **the software stack** layered on top of this hardware that truly unlocks autonomy. From data collection and training to machine vision, software is what enables robots to operate in dynamic, real-world environments. The following sections explore the key software layers driving this transformation.



D. Data & Training: The foundation of learning

High-quality, diverse data is essential for teaching robots how to act in the real world and involves several critical steps. Startups like Anyverse generate high-quality synthetic data tailored to robotic perception, while Sensei Robotics provides an outsourced training data collection. Complementing these, Encord offers a multimodal AI data platform to label, curate, and manage datasets; ReSim enables scalable, cloud-based virtual testing of robotics and autonomy systems; and Rerun delivers an open-source visualization and data stack for logging and analyzing multimodal robotics and vision data in real time. Together, these companies are building the infrastructure needed to accelerate reliable robotics development. Several data collection approaches are being explored today:

- **Teleoperation**, where humans control robots via joysticks or haptic devices, offers high-quality demonstrations but is hard to scale.
- **AR-based data** allows operators to guide robots in augmented reality environments, but adoption remains limited by headset usage.
- **Simulation environments** enable rapid iteration and large-scale experimentation, though transferring models to the real world remains a challenge.
- **Video learning** is a promising but early-stage approach that trains robots using third-person videos such as YouTube, though it suffers from a lack of physical interaction.

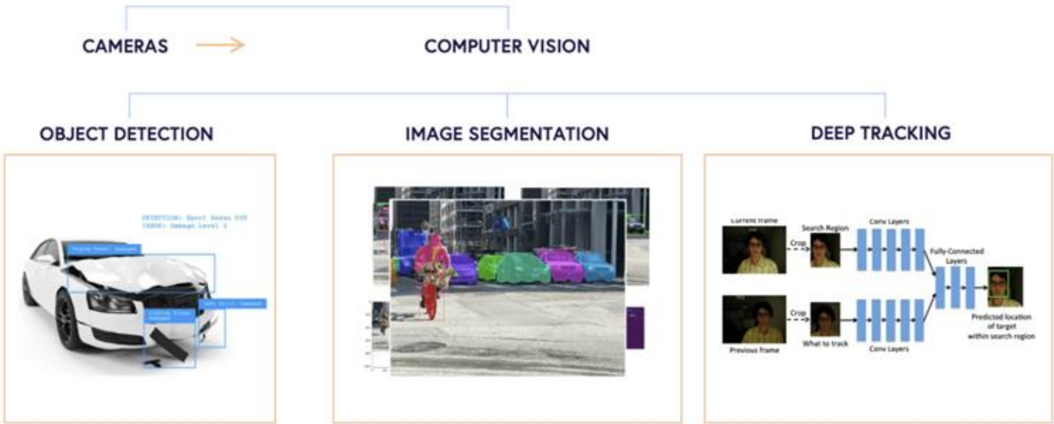
Training sits at the heart of robotics progress. To handle real-world complexity, companies rely on advanced simulation and model training techniques. Hyperscalers like NVIDIA (Cosmos) and Meta (PARTNR), and open-source tools like Gazebo and Hugging Face (LeRobot) are shaping foundational infrastructure. Google's Gemini for the Physical brings embodied reasoning into play, while startups like

Genesis are building full-stack training platforms. European players such as Mistral (Les Ministraux), Flexion, Vsim, and Phospho are also pushing the frontier – offering edge optimized models and training infrastructure to help robots reason, learn, and act autonomously in complex environments. It spans multiple methods:

- **Reinforcement learning** is used to teach robots through trial and error, with success in tasks like dexterous manipulation or dynamic control.
- **Imitation learning** allows robots to learn from human demonstrations.
- **Curriculum learning** allows robots to learn tasks in a structured sequence, starting from simple tasks and gradually progressing to more complex ones – inspired by human education.
- **Digital twin** is a virtual replica of a physical robot and its operating environment, used to simulate behavior, test strategies, and refine performance.

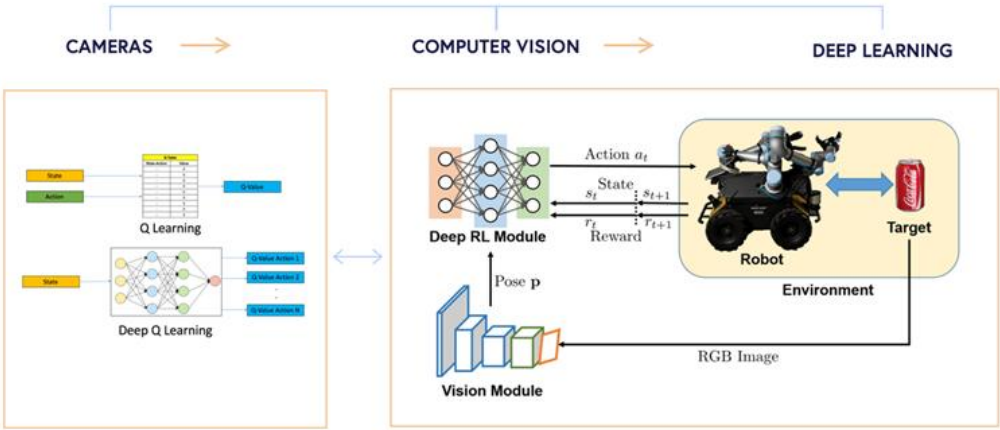
E. Machine vision: Bridging perception and action

Powered by computer vision, sensors (cameras) can now detect and segment objects, track movement, and understand scenes and spatial context. This enables robots to perform essential tasks like navigation and interaction with humans and objects. As vision models improve, robots are increasingly capable of interpreting complex environments with near-human-level perception.



The autonomous robotics future is around the corner – Bessemer Venture Partners

But the extraordinary challenge for robots is to become autonomous. **Autonomy in robotics demands not just precise control, but contextual understanding. Deep learning and GenAI** provide the neural backbone that enables robots to interpret sensory inputs and respond intelligently. One of the most transformative developments is the rise of VLA models, which link perception (vision), intent (language), and decision-making (action). These models allow robots to follow natural language instructions, perceive visual scenes, and make context-aware decisions – removing traditional programming barriers and enabling intuitive human-robot interaction.



[The autonomous robotics future is around the corner – Bessemer Venture Partners]

A growing wave of startups is translating these advances into real-world applications. Inbolt enables robots to make real-time visual decisions in dynamic environments, while Sensmore retrofits heavy machinery with embodied AI and 4D radar for collision avoidance and autonomous operation. Flink, spun out of ETH Zurich, provides plug-and-play software that lets robots see, reason, and act within minutes, and Sereact develops AI systems like PickGPT to power zero-shot manipulation and visual tasks in logistics and warehousing.

F. Foundational Models: Toward general-purpose robotics

The move from narrow, task-specific robots to general-purpose embodied intelligence is being driven by foundation models trained on large-scale, multimodal datasets. These models offer: (i) cross-platform generalization – one model can operate across different hardware platforms, (ii) semantic understanding of the physical world – going beyond geometry to reason about intent and function, and (iii) transferability of learning – knowledge gained in one task or domain can be reused elsewhere. Companies like Skild AI and Physical Intelligence are developing large-scale models that can learn from demonstrations, interpret commands, and make autonomous decisions in real time. Arondite provides software to orchestrate autonomous systems, while General Robotics is building general-purpose robotic intelligence with plug-and-play skills. However, challenges remain in aligning these models with physical embodiment.

G. Fleet Management

As robotics deployments scale, especially in logistics and delivery, **fleet management systems have become essential for coordinating, monitoring, and optimizing multiple robots in real time.** These platforms handle task allocation, traffic control, energy optimization, and predictive maintenance, ensuring that robots operate efficiently as a team. Companies like Formant and InOrbit offer solutions that provide centralized dashboards, analytics, and remote-control capabilities. Effective fleet management is crucial for scaling operations while avoiding collisions, idle time, and inefficiencies.

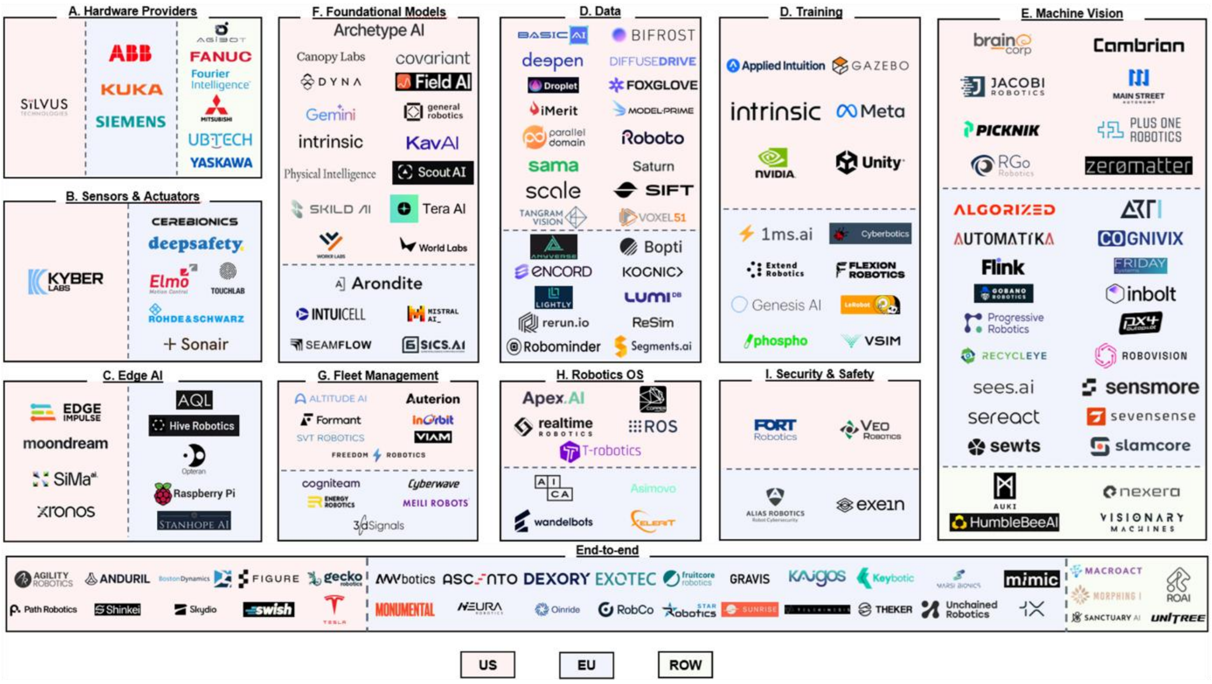
H. Robotics OS

Robotics OS serve as the foundational software layer that enables robots to perceive, plan, and act by managing how different components – sensors, actuators, algorithms – **interact**. Much like operating systems in personal computers, these platforms provide middleware to simplify development and allow for modular design. The most widely used framework is ROS, with its more robust successor ROS2, which supports real-time communication, multi-robot systems, and industrial-grade deployments. However, several alternatives are emerging such as Apex.AI or Realtime Robotics.

I. Security & Safety

As robots operate closer to humans and handle sensitive tasks, **safety and security are critical enablers of trust and adoption**. On the safety side, systems must comply with strict standards to avoid harm through redundancy, fail-safe systems, and real-time monitoring. For security, protecting robots from cyberattacks or data leaks is increasingly important, especially in healthcare and defense. Startups like Fort Robotics and Alias Robotics are building safety and cybersecurity stacks for robotic systems, while Exein embeds AI-powered security at the firmware level — mitigating attacks before they escalate. Regulators are also beginning to define frameworks for certification and compliance across sectors.

Market Mapping



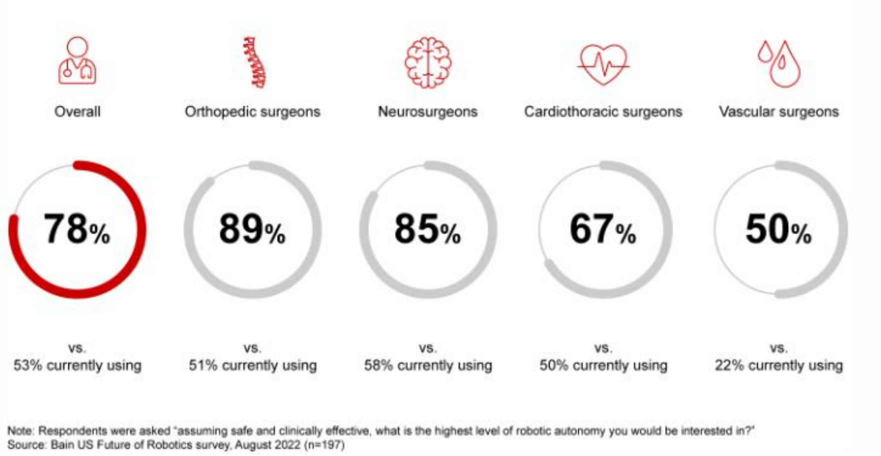
IV. The robotics bet: backing startups that deliver real ROI

As noted in Part 1, robotics tightly binds form and function, with humanoids standing out as a promising path despite being at an early and capital-intensive stage. In contrast, **verticalized robots seem more pragmatic and built for clearly defined, high-ROI use cases in structured environments**. These robots trade general-purpose flexibility for performance, speed of deployment, and return on investment. They have already demonstrated traction in sectors like medical, manufacturing, logistics, and construction.

That said, humanoid robots may still play an important role in general-purpose, unstructured environments such as homes or office buildings – where flexibility or dexterity matter more than efficiency. Over time, a few standard form factors may emerge just as the chatbot interface became the default UI for consumer AI. Japan illustrates this potential particularly well: its national strategy actively promotes robotics to overcome the effect of an aging population.

AVP believes that **certain historically labor-intensive verticals are particularly well-suited for robotics.** By taking a vertical-specific approach, robotics companies can develop deep expertise within a segment and build a competitive moat through data advantages or by solving unique, industry-specific problems. Below are some of the key verticals that are ripe for disruption:

- **Robotics is transforming healthcare**, where precision is crucial, and errors can be life-threatening. While used across many areas, surgery stands out for its clear benefits – offering greater consistency, fewer errors, and improved patient outcomes. The surgical robotics market has expanded rapidly, growing from approximately $800m in 2015 to around $3.5bn today, with 78% of surgeons interested in adopting robotic systems. The da Vinci System, the most widely used multiport robotic surgery platform, has been used in more than 12m procedures globally. Public companies like Vicarious Surgical are pushing the frontier further, using a single small incision to insert a camera and two robotic instruments. AI is now accelerating the next phase of development. A recent John Hopkins University study showed that a robot trained through imitation learning achieved accuracy comparable to that of experienced surgeons. When applied, this approach eliminates the need for manual programming and allows surgical robots to learn new procedures within days. This advancement is accelerating adoption and building on the clinical benefits already demonstrated.



Percentage of Surgeons Interested in Surgical Robots

- **The manufacturing sector** has relied on robots for decades. It was the first industry to adopt them. Today, there are more than 4m industrial robots in use, with the automotive industry leading in adoption. Many tasks done in a factory setting such as pick-and-place and inspection, traditionally done by humans, are increasingly being replaced by robots. Macro trends are driving this shift: **nearshoring, an aging workforce, and rising labor costs are pushing manufacturers**. Robotics adoption can significantly enhance efficiency, quality, and reduce costs. In fact, wages in manufacturing are expected to grow 125% whereas the average cost of industrial robots is expected to decrease 58% between 2005 and 2030. We follow in particular vertically focused companies like (i) Energy Robotics, which is developing a fleet management

-platform for inspection or (ii) Maven Robotics, which is developing robots for various high-repetition manufacturing tasks. In contrast, humanoid robotic platforms developed by companies like Agility and Figure are designed to serve as flexible, general-purpose workers on the factory floor, offering more horizontal capabilities and may not perform as well on specialized tasks.

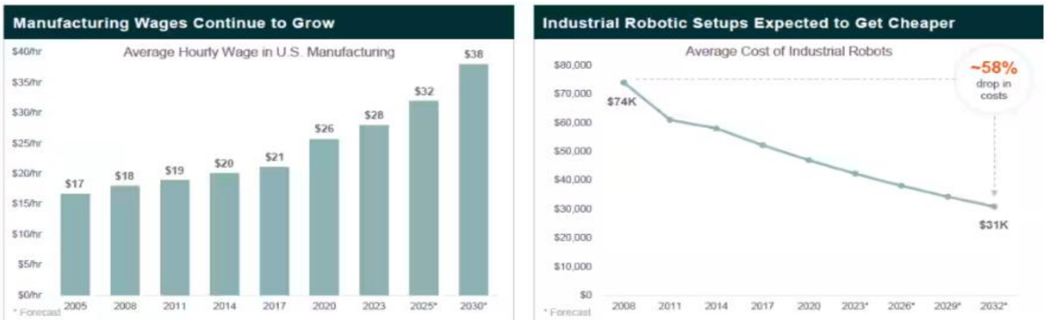
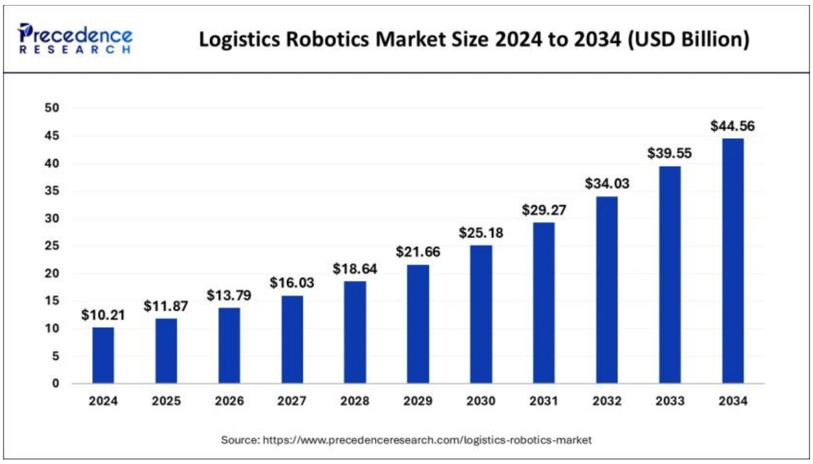


PHOTO: GLOBAL X, OUTLOOK FOR 2025 AND BEYOND

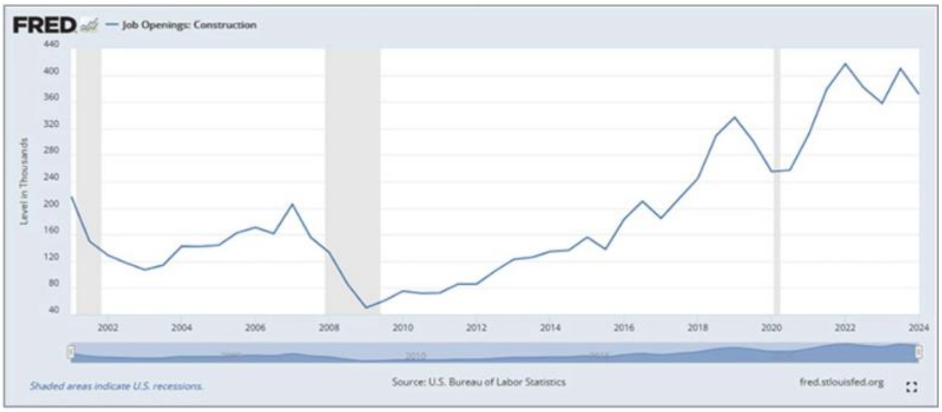
Cost of Manufacturing Wages vs. Robotics Cost

- **The logistics and transportation sector** presents a significant opportunity for robotics automation. **Currently, most warehouses are manually operated with limited automation.** Robots can be deployed across various functions, from container loading and unloading to last-mile delivery, especially with recent AV and computer vision advancements. According to a report by ABI Research, last-mile delivery revenue from robotics is expected to grow by +850%, from $70m in 2022 to $670m by 2030, as companies increasingly adopt them as a convenient delivery solution. **Industry giants like Amazon and Alibaba have set the bar by investing heavily in robotics.** For example, in 2019 Amazon launched Scout, a delivery robot the size of a small cooler that navigates sidewalks. In June 2025, Amazon also announced plans to roll out AI robots capable of completing tasks without human intervention. Other companies are forming partnerships with robotics firms, for instance; Uber Eats plans to deploy 2k Serve Robotics last-mile autonomous delivery robots in the US by the end of 2025. Overall, we expect the logistics landscape to look very different in the coming years.



Logistics Robots Market Size

- **Construction is emerging as an important area for robotics,** offering a safer and more efficient alternative in a traditionally manual and high-risk industry slow to adopt innovation. According to McKinsey, the $12tn global architecture, engineering, and construction (AEC) industry ranks among the least digitized sectors, creating space for disruption. At the same time, **the industry faces acute labor shortages –** approximately 440k positions remained unfilled in 2023, and the National Center for Construction Education and Research (NCCER) projects that ~41% of the current workforce will retire by 2031. Robotics has the potential to drive meaningful impact across the construction lifecycle from preconstruction to on-site building. For example, Dusty Robotics' FieldPrinter autonomously lays out full-scale BIM designs directly onto jobsite floors, helping crews build with greater precision. Meanwhile, Monumental develops mobile construction robots that collaborate with human workers on-site, focusing initially on autonomous bricklaying. While construction has been slow to adopt new technologies, the combination of workforce pressures and automation positions the sector for significant growth in robotics adoption.



Source: U.S. Bureau of Labor Statistics, Job Openings: Construction [JTS2300JOL], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/JTS2300JOL, September 16, 2024.

Job Openings in Construction 2021-2024

Conclusion

This shift across key verticals reveals the growing promise of robotics, evolving from niche automation into a transformative technology category. **Several key trends make this sector increasingly appealing to investors:**

- **Recent breakthroughs in AI**, particularly with foundation models, are enabling robots to generalize across tasks, environments, and hardware. This marks a shift from traditional, rule-based automation to flexible and adaptive systems. As a result, robots can now easily operate in semi-structured environments whereas it was previously way too complex.
- **The robotics technology stack is becoming increasingly modular and software driven.** Startups no longer need to build full-stack solutions from the ground up. Instead, they can focus on specific layers such as fleet orchestration or sim-to-real transfer. This unbundling of the stack has opened a wave of "picks and shovels" opportunities, where infrastructure and developer tools become attractive, standalone investments.
- **Business models are evolving as robotics systems become more intelligent and improve over time.** What began as simple RaaS models – typically pay-per-task – are now shifting toward SaaS-like, usage-

based pricing. These models allow for margin expansion over time as the system learns, delivering compounding value to customers and reinforcing defensibility through network and data effects.
- **The geopolitical landscape is also fueling growth.** Regional superpowers including China and the US are rapidly investing in robotics to support their economies.

Despite the promise, robotics remains a complex domain with **several inherent challenges that investors must carefully consider:**

- **Robotics lags behind in terms of language data and vision data**, with datasets consisting of millions of episodes versus trillions of tokens for LLMs. It limits progress and often requires expensive, task-specific fine-tuning.
- **Robotics sits at the intersection of hardware and software.** Hardware is expensive and slow to iterate, while the integration of sensing, control systems, and AI algorithms introduces further complexity.
- **Robots often come with significant upfront CapEx,** still remaining higher than equivalent human labor for many use cases.
- **Regarding GTM, robotics frequently targets industries** like logistics, agriculture, or cleaning – sectors **with thin margins and slow tech adoption**.
- **While humanoid robots generate long-term potential, they remain far from being commercially viable today.** These systems are still costly to build and train, difficult to deploy in real-world environments, and offer unclear short-term ROI.
- **Like AI, widespread adoption of robotics could lead to short-term dislocations in the labor market** and could disincentivize robotics adoption.

Given the above dynamics, **a successful investment strategy in robotics should focus on:**

- **Startups with a competitive edge in data** have a significant advantage in robotics, where access to high-quality, task-relevant data is a major barrier to entry.
- **Verticalized robotics targeting repeatable, high-frequency tasks in structured or semi-structured environments** tend to benefit from faster GTM, quicker value delivery, and greater capital efficiency. Starting by solving one specific problem extremely well and focusing efforts on a clearly defined use case before expanding can ensure the solution drives real ROI.
- **Middleware and developer tools** that unbundle the stack, such as fleet orchestration, OS, data collection, training tools, and vision algorithms.
- As regulation increases, **opportunities will emerge around cybersecurity, data privacy, and compliance standards** (e.g., ISO 25785-1, NIS2). The need for robust security will grow as robots proliferate across homes or hospitals.
- **Companies that treat hardware as a delivery layer and focus on software** may offer better margins, faster iteration, and higher defensibility.

Alongside these promising areas, **certain segments still present significant challenges and should be approached with caution:**

- **General-purpose humanoids (short to mid-term)** which are exciting with long-term potential but not yet commercially viable at scale.

- **Full-stack robotics startups** try to build everything in-house – capital intensive and slow to iterate.
- **Startups that depend on third-party hardware providers** face several structural risks. This dependency can slow development cycles, limit access to low-level sensor data, and create friction around integration. It also introduces scalability challenges, as updates or changes on the hardware side can disrupt software performance and roadmap alignment, and long-term strategic vulnerability.
- **Robots that lack learning capabilities or adaptability.** We believe that long-term winners will be those whose systems improve autonomy over time.

To conclude, **what once felt like science fiction is now edging into reality.** Westworld painted a world where robots seamlessly integrated into human environments – intelligent, adaptive, and often indistinguishable from us. While we're still far from that dystopian vision, **robotics is definitely entering a new era.**

Today, humanoid platforms continue to inspire and advance rapidly, even if their large-scale deployment remains on a longer-term horizon. In parallel, **more narrowly focused vertically integrated systems are already beginning to demonstrate value**. From factory floors and hospitals to warehouses and construction sites, robots are not just automating repetitive tasks – they are reshaping entire workflows, enhancing precision, and addressing critical labor shortages.

This transformation is fueled by a convergence of breakthroughs: foundation models that enable generalization across tasks, edge AI that unlocks real-time autonomy, and increasingly modular software infrastructure. **Paired with falling hardware costs and rising enterprise demand**, these advances are making robotics more accessible, scalable, and commercially viable than ever before.

At AVP, we are especially focused on software-first, vertically integrated robotics startups with clear ROI, defensible data advantages, and focused GTM strategies. We also believe that infrastructure layers – training platforms, operating systems, and fleet orchestration tools – **represent critical leverage points in the evolving robotics stack**.

For investors, **this is a defining moment**, and the shift from prototype to real-world deployment is underway.

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