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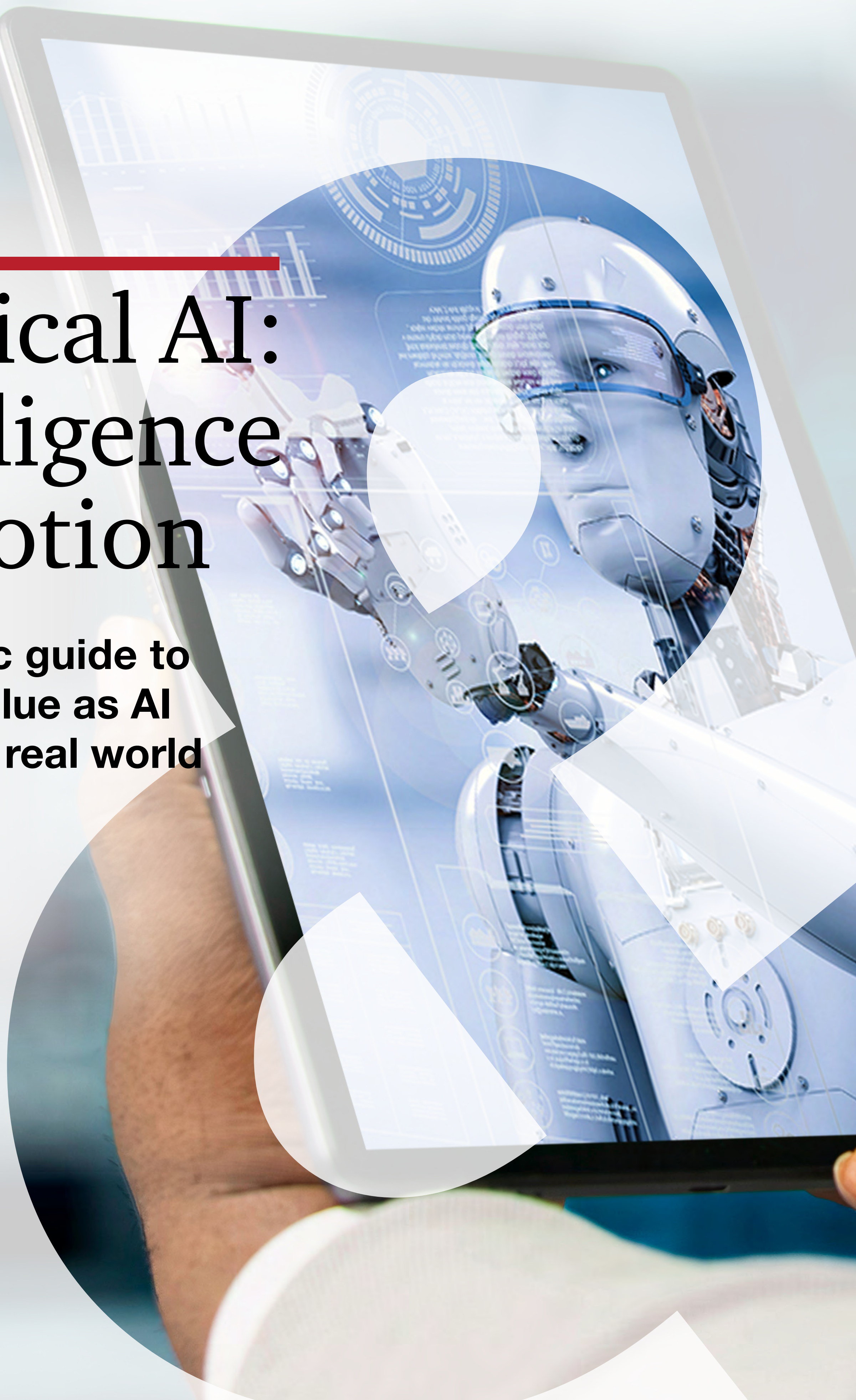
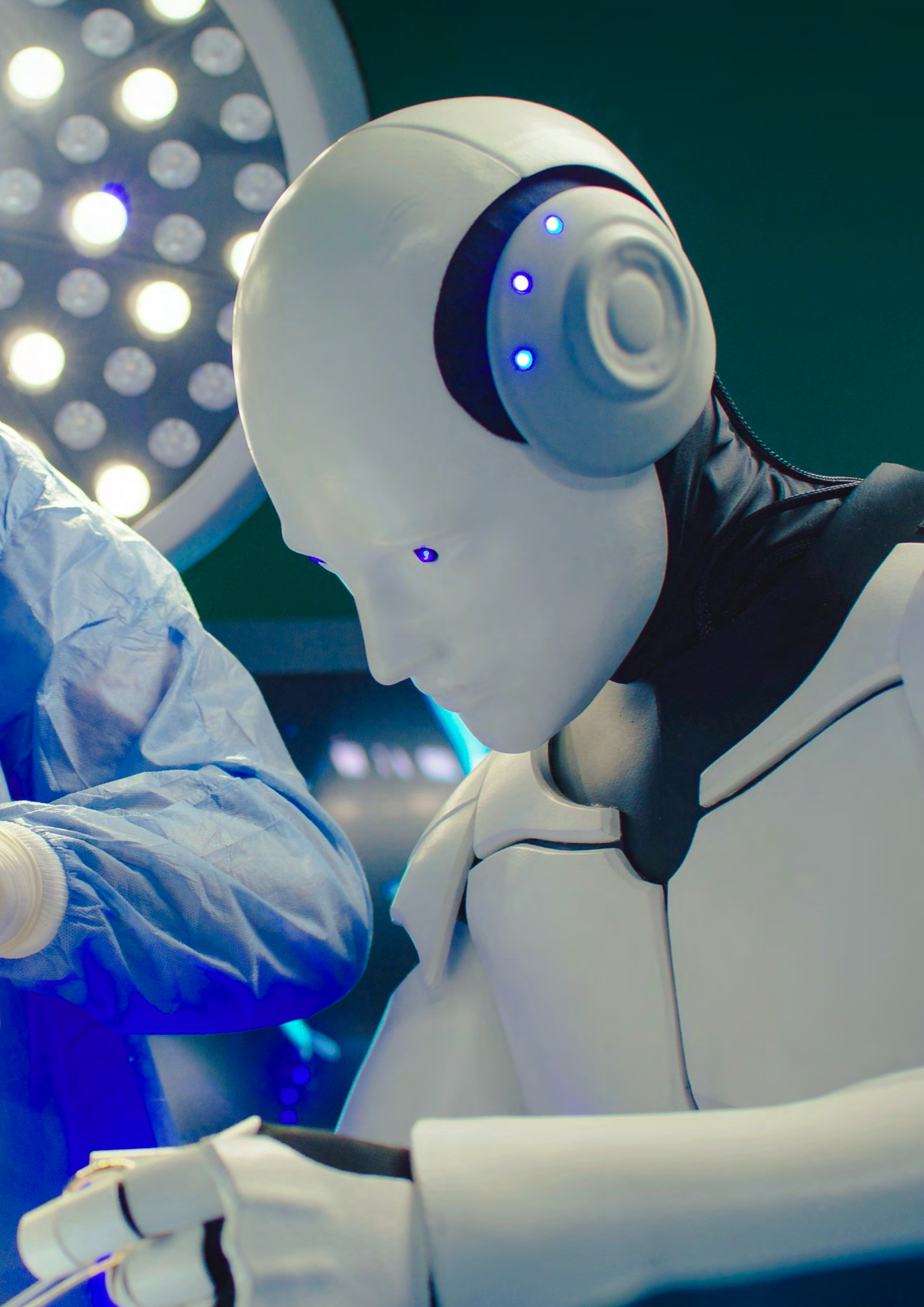
Physical AI: Intelligence in motion

A strategic guide to capture value as AI enters the real world





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EXECUTIVE SUMMARY

Artificial intelligence (AI) is entering a new phase. After Generative AI (GenAI) transformed how digital content is created and Agentic AI enabled software systems to plan and act autonomously, the next step is the extension of AI into the real, physical world. This shift is commonly referred to as Physical AI: AI systems that operate in the world we all know and live in, such as vehicles, robots, drones, or smart infrastructure.

At its core, Physical AI combines three capabilities: sensing, decision-making, and actuation. But unlike purely digital AI systems, Physical AI must operate under real-world constraints such as physics, latency, safety, and reliability. This makes it both significantly more complex and potentially far more valuable.

Across autonomous driving, industrial automation, logistics, humanoid and service robotics, aerospace and defense, healthcare, and entertainment, Physical AI is expected to unlock a global market of ~EUR 430 billion by 2030[1], with upside beyond that as systems scale and mature. Early commercial deployments already exist (such as autonomous vehicles in constrained domains, warehouse robots, robotic surgery assistance, and advanced inspection systems), but most applications remain in the early adoption phase, as significant technological challenges remain. Over the next 3 to 5 years, Physical AI is expected to transition from individual pilots to scaled deployments in selected, high-ROI use cases.

~430bn

Physical AI is expected to unlock a global market of ~EUR 430 billion by 2030

Physical AI is not a single product or technology wave – it is a systems transformation. Value will accrue not only to companies building robots or vehicles, but also to semiconductor suppliers, cloud and data center operators, simulation and software platform providers, infrastructure players, and end users who redesign processes around embodied intelligence. Winners will be those who understand where Physical AI is already viable, where it is not yet ready, and how to position themselves across the evolving value chain.

In short, Physical AI represents the next major chapter of AI-driven value creation. The opportunity is real and large, but it will be realized unevenly, through careful orchestration of technology, economics, and strategy. Understanding this landscape early is becoming a strategic necessity, not a technical curiosity.

1 Source: Strategy& analysis

> "Over the next 3 to 5 years, Physical AI is expected to transition from individual pilots to scaled deployments."
>
> Tanjeff Schadt, Partner at Strategy&

SECTION 1

The Physical AI revolution

AI is expanding from software into the physical economy

The defining challenge of today's AI landscape is not a lack of innovation, but the speed and overlap of progress. In previous technology waves – such as the internet or enterprise software – capabilities evolved over decades, giving companies time to experiment, standardize, and converge on winning models. By contrast, modern AI advances arrive in rapid succession, often before the previous wave has been fully absorbed.

Many organizations are still translating the implications of GenAI – large models that can create text, images, code, and designs – when the next application class is already gaining momentum. Agentic AI extends these systems by enabling autonomous planning, tool use, and execution within digital environments. Physical AI represents the next step: AI systems that operate in the real world, interacting with physical environments. These developments do not replace one another; they stack and expand the scope of AI. Together, they mark a broadening of AI from software into the material economy.

For executives, this creates a growing sense of uncertainty. Which technologies are incremental, and which are structurally transformative? Where should investment focus – models, hardware, platforms, ecosystems, or use cases? Physical AI is often perceived as futuristic, yet early deployments already exist across logistics, manufacturing, mobility, healthcare, and defense.

What matters strategically is not whether Physical AI will arrive – it already has – but how organizations choose to participate. The opportunity is not limited to building robots or autonomous vehicles. It spans the full value chain, including hardware, software, and services: semiconductors, data centers, simulation platforms, software stacks, systems integration, and end-user industries. Across these layers, we estimate a combined Physical AI-related market potential of ~EUR 430 billion by 2030[2]. The critical question is how companies position themselves within this emerging system.

Physical AI turns AI from a tool into an autonomous actor

Physical AI refers to AI systems that perceive the physical world, reason about it, and act within it. These systems are embedded in machines – vehicles, robots, drones, medical devices, or infrastructure – and operate under real-world constraints such as physics, latency, safety, and cost. Where GenAI focuses on producing digital artifacts, and Agentic AI focuses on coordinating digital actions, Physical AI focuses on physical work: moving objects, navigating environments, manipulating tools, and interacting with humans. The defining shift is that AI becomes an autonomous actor, not just a decision-support tool.

2 Source: Strategy& analysis

Three tightly-coupled capabilities define Physical AI systems:

1. Sensing	Multimodal perception systems (vision, lidar, radar, audio, force, tactile) transform raw sensor data into an understanding of the environment – e.g., a robot interpreting a cluttered warehouse or a surgical system detecting tissue properties.
2. Decision-making	AI models evaluate options under uncertainty, integrating perception, memory, and objectives to plan actions. This increasingly includes foundation models, reinforcement learning, and predictive models.
3. Actuation	Decisions are translated into physical actions via motors, control systems, and mechanical structures – robotic arms, wheels, legs, grippers, or exoskeletons.

These systems differ fundamentally from digital AI. Errors are not just wrong outputs – they can cause physical damage, safety incidents, or operational downtime. As a result, Physical AI must be engineered as an end-to-end system, not as isolated software components.

Technology convergence has moved Physical AI from theory to practice

The idea of intelligent machines interacting with the physical world is decades old. What has changed is practical feasibility. Converging technologies have moved Physical AI from research ambition to commercial experimentation.

First, learning at scale has improved. Foundation models trained on large volumes of video, simulation, and demonstration data enable systems to generalize across tasks and environments, reducing the need for narrowly-engineered behaviors.

Second, simulation and synthetic data have become central. High-fidelity simulators and digital twins allow training, testing, and validation in virtual environments, significantly reducing cost, risk, and time-to-deployment.

Third, compute has shifted toward hybrid cloud-edge architectures. Cloud infrastructure supports large-scale training and simulation, while edge accelerators enable real-time perception and control directly on machines.

Fourth, hardware components have matured. Sensors are more capable and affordable, actuators deliver higher precision and power density, and batteries enable longer operating cycles – eventually closing the gap between AI decision-making and physical execution.

Finally, world models are emerging as a core enabler. World models allow Physical AI systems to internally represent and predict how the environment evolves over time. This enables simulation-before-action – anticipating consequences before execution – and is critical for safety, robustness, and autonomy. As these models improve, Physical AI systems become more adaptive and capable of operating in complex, dynamic environments.

Physical AI unlocks value first where automation pressure is highest

Physical AI adoption accelerates in contexts where automation delivers high economic value, environments are partially structured, and human labor is scarce, expensive, or exposed to risk. Several verticals stand out (*see Exhibit 1, next page*).

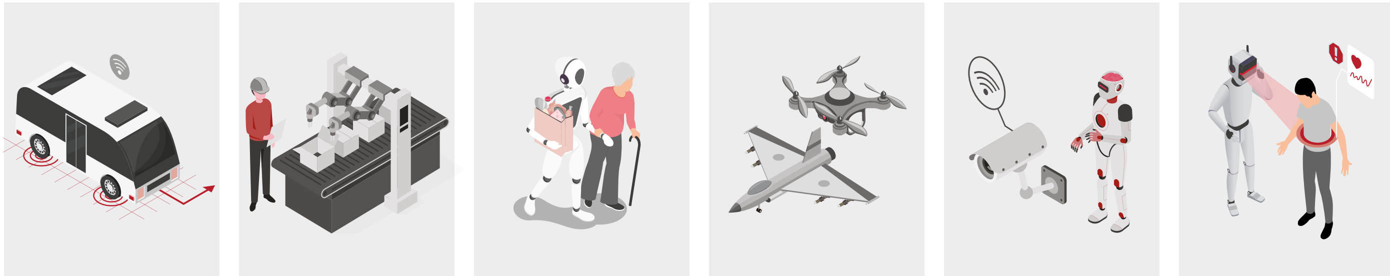
Understanding the technology stack is now a strategic necessity

As Physical AI moves from individual pilots toward scalable platforms, competitive advantage increasingly depends on mastering the underlying technology stack – from models and simulation to compute, sensors, and systems integration.

The next chapter examines this technology landscape in detail, assessing maturity, bottlenecks, and where breakthroughs are still required.

EXHIBIT 1

Selected key verticals for Physical AI and Physical AI-related market potential by 2030



Autonomous driving	Industrial and smart infrastructure	Humanoids and service robots	Aerospace and defense	Entertainment	Health and medical
Autonomous vehicles, such as robotaxis, trucks, shuttles, and delivery platforms, represent the largest Physical AI opportunity, and are already being deployed at scale. Progress is driven by advances in perception, world models, and large-scale fleet learning	E.g., factories, warehouses, ports, and cities are early beneficiaries. Autonomous mobile robots, robotic picking and assembly, and AI-driven traffic or utility management deliver near-term ROI. Robots-as-a-Service models and labor shortages accelerate adoption	Humanoid robots address environments designed for humans, such as stairs, doors, and tools. Early deployments focus on logistics and hospitality; longer-term potential lies in healthcare and elder care. Progress depends on dexterity, energy efficiency, and continuous learning	Defense and space often lead early adoption due to high human risk and strategic urgency. Applications include autonomous drones, unmanned vehicles, robotic maintenance, and coordinated multi-agent systems	Physical AI enables advanced systems for consumers and creators, such as interactive animatronics for theme parks and autonomous camera systems. Software-defined behavior and over-the-air updates differentiate experiences at scale	Robotic surgery assistance, hospital logistics robots, rehabilitation systems etc. improve precision and efficiency. Regulatory requirements slow adoption, but demographic pressure and staff shortages are strong drivers
~EUR 171bn	~EUR 69bn	~EUR 68bn	~EUR 50bn	~EUR 37bn	~EUR 5bn

Source: Strategy& analysis; the selected verticals are not collectively exhaustive

SECTION 2

Technology landscape and maturity

Core capabilities of Physical AI

Advances are being made in the three core capabilities of Physical AI, thereby significantly improving real-world performance. Selected trends are displayed in *Exhibit 2*.

EXHIBIT 2

Physical AI capabilities and selected key trends

Capability	Selected trends
Sensing	• Sensor-compute co-design: tailoring sensors and chips together to enable real-time understanding of multimodal data • Neuromorphic fusion: brain-inspired, event-driven compute that fuses different sensor types with ultra-low power and latency
Decision-making	• Generalist models: on-device algorithms that learn from a wide range of scenarios and generalize across multiple use cases • Multimodality of foundational models: next-gen models that can take in text, images, and sensor data in one system
Actuation	• Soft/Bio-inspired: muscle-like, compliant materials that enable gentle, safe interaction with people and objects • Advanced control algorithms: adaptive and predictive software that optimizes performance and extends component life
Infrastructure	• Managing energy efficiency: continuous multimodal streaming is more energy-intensive than text-only LLM workloads • Edge-cloud collaboration: Devices making real-time decisions on the edge and complex reasoning in the cloud

Source: Strategy& analysis

These capabilities operate under strict constraints on energy, safety, and system reliability, placing new demands on the underlying infrastructure. Physical AI devices require high-performance compute, fast connections, and high sensor data throughput, supported by close collaboration between cloud data centers and edge devices. In practice, this means that many systems are now limited less by raw compute and more by memory and data movement, especially when running large models in real time at the edge (*see Exhibit 2, previous page*).

Physical AI and world models

Physical AI systems can become more powerful when paired with world models – software models that learn how a particular environment behaves over time. These models are a core software component of Physical AI: They help the system anticipate what is likely to happen next and choose better actions as a result. First, world models allow teams to train and test robot decision-making ("policies") in virtual environments before deploying in the real world. Second, in a simplified ("distilled") form, they support real-time prediction and state estimation on the physical device.

World models go beyond classical digital twins. Digital twins typically mirror the current state of an asset or process. A world model, by contrast, is optimized to predict how the environment will evolve under different actions, and to support learning and decision-making in that environment.

Today, world models are constrained by memory efficiency, data movement, and the persistent "sim-to-real" gap. Early approaches focused on video prediction. Newer systems are multi-modal, combining sensor data, language, and abstract task structure.

Embodiment gap versus human performance

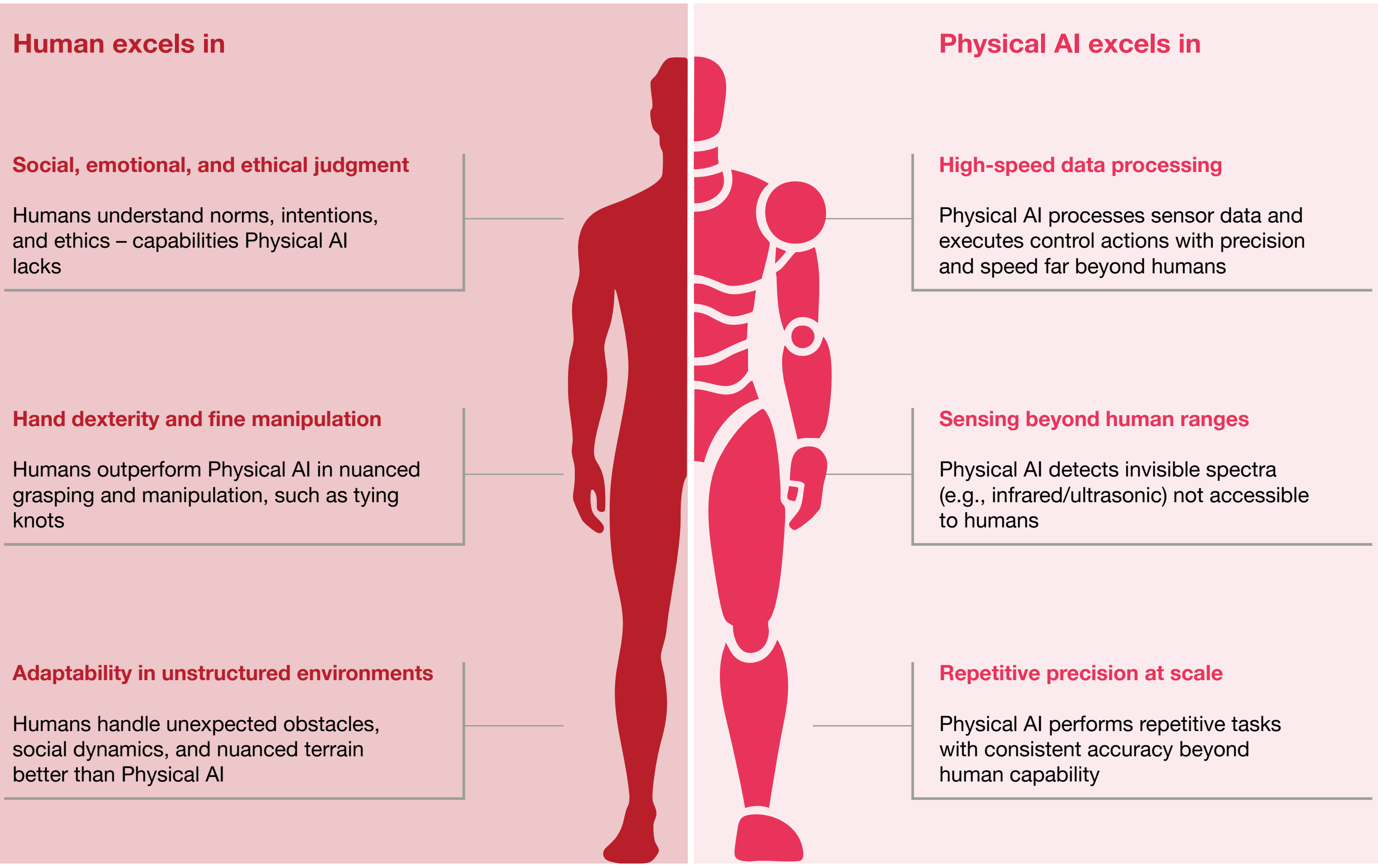
Despite rapid progress, Physical AI still lags humans in adaptability to highly unstructured environments, manipulation of diverse objects, and interacting with humans in context-aware ways. These embodiment gaps reduce reliability and versatility outside controlled settings, and closing them is a prerequisite for human-level autonomy.

At the same time, Physical AI now exceeds human performance in constrained tasks requiring high precision, repetition, advanced sensing, and rapid control loops. These asymmetries explain why early commercial success is concentrated in logistics, manufacturing, and mobility rather than general robotics (*see Exhibit 3*).

As Physical AI systems transition from research to scaled deployment, value creation increasingly shifts away from standalone hardware toward compute, foundational software, and system integration. Chapter 3 quantifies how this transition reshapes markets and value pools.

EXHIBIT 3

Capabilities of a human versus capabilities of Physical AI, using the example of a humanoid robot



Source: Strategy& analysis

SECTION 3

Market dynamics and value pools relevance of Physical AI

Physical AI will not diffuse uniformly. The automotive sector will lead adoption, accounting for roughly EUR 171 billion of the ~EUR 430 billion global Physical AI systems market by 2030[3], as autonomous driving reaches a technical tipping point: Modern semiconductors and Physical AI software now support the perception, planning, and control needed for safe deployment at scale. Industrial automation and warehousing will be the next major cluster, representing about EUR 69 billion, as their structured layouts, external sensor networks, and repetitive workflows reduce integration complexity and make returns more predictable. Entertainment will adopt Physical AI for immersive experiences, and defense customers will also move early, driving a sizeable share of incremental demand to gain an operational edge in complex, contested environments.

For Europe, we estimate that early Physical AI adoption will represent ~EUR 80–110 billion by 2030[3], driven primarily by automotive and industrial automation. Targeted positioning will be needed to maximize capture of upstream value.

3 Source: Strategy& analysis

Key value components
Physical AI will not just reshape who adopts first, but also where value concentrates along the technology stack – for investors and suppliers, three segments stand out as the largest and most attractive value pools:

Digital infrastructure (datacenter and edge compute, memory)	High-performance compute and high-bandwidth memory are the core bottleneck for training and real-time inference on large models, concentrating value and pricing power in a small set of leading chip suppliers. Example: NVIDIA underpins many autonomous driving and robotics programs with its DRIVE and Jetson platforms. It captures value through high-margin automotive and edge AI SoCs, plus tightly integrated software stacks and toolchains.
Foundational models (“AI brains”)	Multimodal, large-scale models that perceive, plan, and act autonomously are the key differentiator versus pre-programmed robots, capturing a large share of software value. Example: Figure AI develops humanoid robots powered by proprietary foundational models that can generalize across logistics and manufacturing tasks, scaling value primarily through software and data.
Simulation platforms and world model software	High-fidelity simulation and learned world models are critical to Physical AI because they allow training, testing, and validation in virtual environments before deployment, narrowing the sim-to-real gap and reducing cost and risk. Example: World Labs develops world models that let embodied agents “imagine” future states and outcomes, enabling OEMs and operators to train and evaluate control policies largely in simulation and cut costly real-world data collection.

Other important but somewhat smaller value pools include datacenter and AI services, Physical AI OEMs, sensors, and system integrators. *Exhibit 4, next page* maps these Physical AI value pools and illustrates which parts of the stack are positioned to capture the largest share of value.

For companies aiming to capture a significant share of the value potential of Physical AI, it is imperative to make conscious decisions on where and how to play in this highly competitive and fast-changing industry. To provide guidance to executives of firms that operate along the Physical AI stack, the next chapter groups these value pools into seven strategic arenas in which companies can compete and collaborate to capture that value.

EXHIBIT 4

Distribution of value along the core Physical AI value chain

Algorithms

Datacenter/AI services (5%)	Simulation platform/world models (10%)	Foundational models (20%)
• Deliver managed infrastructure for training, deploying, monitoring, and scaling AI workloads • Reduce time-to-market and operational complexity by providing on-demand compute, data pipelines, orchestration, and fleet-scale analytics for physical systems	• Create virtual environments and learned representations of the world for training, testing, and validating AI policies • Allow safe, fast, and low-cost iteration on perception and control, enabling learning from billions of interactions before deployment	• Large, general-purpose AI models for vision, language and multimodal control that can be adapted to many downstream tasks • Provide versatile "brains" that can be fine-tuned for perception, planning, and interaction across different robots, domains, and workflows, dramatically reducing custom development

Physical device

Datacenter compute (15%)	Edge compute (10%)	Memory (10%)	Actuators (10%)	Sensors (8%)
• Power the large-scale inference and training that drive perception, planning, and coordination algorithms across fleets of physical systems	• Enable real-time perception, control, and autonomy without constant cloud connectivity for reliability, safety, and responsiveness on the edge	• Support high-throughput, low-latency data access that keeps AI pipelines in datacenters and at the edge running efficiently and at scale	• Turn AI decisions into precise actions, enabling robots and machines to reliably manipulate, move, and interact with their environments	• Provide the raw, high-fidelity inputs AI needs to perceive and understand its environment providing AI feedback loop

OEMS (7%)

- Design, build, integrate, and support complete AI-powered machines such as robots, vehicles, devices and their software stacks
- Translate AI capabilities into turnkey physical products and services, owning the last mile of integration, reliability, compliance, and user experience

System integration (5%)

- Deliver professional services to plan and execute the implementation of Physical AI devices into existing workflows for clients seeking to introduce Physical AI in their organization
- Enable customers of Physical AI firms to fully utilize and monetize their Physical AI capabilities

x% Approximate share of total market value

Source: Strategy& analysis

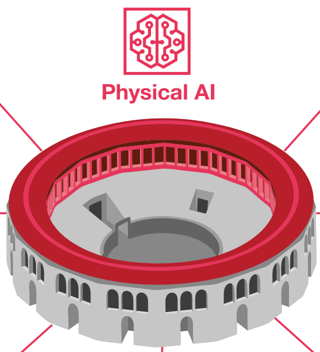
SECTION 4

Strategic opportunities

Building on the value pools outlined in Section 3, the era of Physical AI is taking shape around seven key arenas (*see Exhibit 5)* that govern how intelligent machines are built, deployed, and controlled. Each arena comes with its own value creation strategy, control points, and risks, for both global leaders and European companies that need to balance competitiveness with strategic independence.

EXHIBIT 5

Key strategic arenas shaping value creation and competitive advantage in the emerging Physical AI ecosystem



1. Foundational world model

Foundational world models are AI models that can understand, simulate and predict physical, 3D and temporal dynamics of the real world across various scenarios with multiple modalities such as visual, audio and speech

2. Domain-specific models

Domain models encode sector-specific processes so robots and autonomous systems can operate reliably in environments like factories, construction sites, or hospitals, while reducing required compute power and latency compared to general AI models

3. Edge semiconductors

Edge semiconductors provide specialized compute for multimodal fusion, motion planning, and closed-loop control directly on devices

4. Precision sensors and actuators

High-precision sensing and advanced actuation underpin reliable, safe, and human-compatible Physical AI performance

5. Standards and modularization

Standards for chiplets and interoperability shape how components interconnect, how ecosystems form, and how dependent players become on single vendors

6. OEM and solution providers

OEMs and integrators deploy Physical AI systems at customer sites, combining hardware, models, orchestration, and field services

7. Sovereignty

Sovereignty in Physical AI is about a region's ability to control critical technologies, infrastructure, and governance for intelligent physical systems

Source: Strategy& analysis

1. Foundational world models

Foundational world models are AI models that can understand, simulate and predict physical, 3D and temporal dynamics of the real world across various scenarios with multiple modalities such as visual, audio and speech.

Value creation strategy	High-margin APIs and cloud robotics services generate recurring revenues from model updates, simulation, digital twins, and fleet learning
Control points	Massive compute, proprietary data pipelines, and cloud distribution allow a few hyperscalers to set de facto standards and APIs
Risks	Concentration in a handful of global players creates lock-in and geopolitical exposure for OEMs and regions like Europe

2. Domain-specific models

Domain models encode sector-specific processes so robots and autonomous systems can operate reliably in environments like factories, construction sites, or hospitals, while reducing required compute power and latency compared to general AI models.

Value creation strategy	Bundling domain models with orchestration, middleware, and lifecycle services supports premium pricing and sticky positions in industrial ecosystems
Control points	Deep domain expertise, access to brownfield sites, and integration into existing equipment create strong local moats and high switching costs
Risks	Fragmentation across industries and reliance on a few anchor customers can limit scale and increase exposure if standards or procurement preferences shift

3. Edge semiconductors

Edge semiconductors provide specialized compute for multimodal fusion, motion planning, and closed-loop control directly on devices.

Value creation strategy	Vendors of inference accelerators and edge platforms earn attractive margins from long-lifecycle, safety-critical components
Control points	Early design wins, certification, and tightly-coupled SDKs and tool-chains give a few suppliers outsized influence over Physical AI stacks
Risks	Supply chain concentration, export controls, and long design cycles expose downstream players and import-dependent regions to systemic risk

4. Precision sensors and actuators

High-precision sensing and advanced actuation underpin reliable, safe, and human-compatible Physical AI performance.

Value creation strategy	Makers of products, such as visual sensors, force-torque sensors, metrology, and compliant actuators, capture value via specialized, high-reliability components
Control points	Sensor-model co-design and strong mechatronics capabilities, proven in robotics and automation, create defensible positions and preferred supplier status
Risks	Capital intensity, exposure to industrial cycles, and commoditization pressure can erode margins for hardware-focused players

5. Standards and modularization

Standards for chiplets and interoperability shape how components interconnect, how ecosystems form, and how dependent players become on single vendors.

Value creation strategy	Standard-setters differentiate by time-to-market and can monetize via licensing, services, and by steering demand toward their own compatible products
Control points	Early influence over interconnects, packaging, and interfaces establishes long-term architectural control in the supply chain
Risks	Proprietary or fragmented standards risk lock-in, delayed adoption, and weaker competitiveness for late-moving regions

6. OEM and solution providers

OEMs and integrators deploy Physical AI systems at customer sites, combining hardware, models, orchestration, and field services.

Value creation strategy	Robots as a Service, subscriptions, and lifecycle services create recurring revenues and deep customer relationships
Control points	Direct access to end users, deep workflow integration, and control over fleet operations and data provide strong stickiness and learning advantages
Risks	High integration complexity, capex demands, and operational risk at customer sites can limit scalability and compress margins

7. Sovereignty

Sovereignty in Physical AI describes a region's ability to control critical technologies, infrastructure, and governance for intelligent physical systems.

Value creation strategy	Regions with sovereign capabilities in compute, models, cybersecurity, semiconductors, and industrial AI can anchor local value chains and capture more downstream activity
Control points	Control over compute, foundational models, and key hardware provides structural negotiating power for governments and industry
Risks	Dependence on foreign platforms creates geopolitical and economic vulnerability, while uncoordinated sovereignty efforts risk fragmentation and slower innovation

Firms must understand these strategic arenas to focus on those parts of the Physical AI market where their capabilities can underpin a sustainable advantage. Given the complexity and high financial requirements of the Physical AI market, only those firms that follow a strategy that identifies the capabilities which still need to be built up and how to capture value will be able to create a winning proposition.

SECTION 5

Outlook and call to action

Intelligence is moving beyond the screen. For the first time, AI systems can perceive, decide, and act in the physical world – not as tools waiting for commands, but as autonomous agents reshaping how physical work gets done.

This changes the strategic calculus. Digital AI disrupted information work; Physical AI will disrupt physical operations – factories, logistics, infrastructure, care. The companies that control how machines understand and interact with the physical world will hold structural advantages for decades.

The window to shape this landscape is narrow. Foundational models, simulation platforms, and semiconductor architectures are being defined now. Data flywheels are spinning up. Standards are forming. Within 3–5 years, the first generation of Physical AI leaders will be established – and the cost of catching up will be prohibitive. To become part of this group, strategic decisions on platform partners, data strategy, and in-house capabilities must be taken within the next 12–24 months.

Three questions require immediate executive attention:

1. Where will you compete – and where will you depend?

Physical AI rewards different capabilities across its seven arenas. Few organizations can compete in all arenas. The critical decision is not just where to invest, but where you are willing to accept dependency – and on whom. Platform choices made today will constrain strategic decisions for years.

2. What proprietary assets can you build before the window closes?

Data, domain expertise, and operational environments are defensible. Generic capabilities are not. In Physical AI, proprietary advantage often resides with those who operate in the physical world at scale, such as manufacturers, logistics providers, and industrial operators. The firms best positioned are those converting their physical operations into training grounds – capturing real-world data that cannot be replicated in simulation.

3. How do you move fast while keeping strategic optionality?

Pilots are necessary but insufficient. The goal is not experimentation – it is building conviction on where to scale. This requires tight iteration between technology, operations, and economics, pressure-testing use cases against real constraints.

The organizations that answer these questions decisively – and act on them – will define the first generation of Physical AI leaders. Those that delay will find themselves building on architectures, standards, and platforms they did not choose, competing for value in arenas where others set the rules.

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